PUBLISHED PAPERS
AND ADDRESSES
OF
JOHN CAMPBELL MERRIAM

VOLUME II

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Various Faunas of California

Fauna of Rancho La Brea

Faunas of California, Oregon, and Idaho

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MAMMALIA

VARIOUS FAUNAS OF CALIFORNIA

SIGMOGOMPHIUS LE CONTEI

A NEW CASTOROID RODENT FROM THE PLIOCENE NEAR BERKELEY, CALIFORNIA

CONTENTS

OCCURRENCE

THE fossil rodent remains here described and referred to the Castoridæ or beaver family, were found by the writer, about two years ago, near Bald Peak, two miles east of Berkeley. The fresh-water beds in which they were found form part of a very thick series of gravels, clays, limestones, and eruptives belonging, according to Prof. A. C. Lawson, to the lower division of the Pliocene.[1]

At the point where the rodent bones were found, the clays contain abundant but fragmentary organic remains, including shells of *Limnæa contracosta*, Cooper; *Planorbis pabloanus*, Cooper; *Anodonta Nuttaliana*, Lea var. *lignitica*, Cooper; *Cypris*, nov. sp.; *Ancylus* sp.; and *Helix* sp. Teeth of *Lepus* (?) and the dentary bone and teeth of a lizard closely related to *Lacerta*, were also found in this stratum. In a semi-lignitic layer a short distance above that containing *Limnæa*, etc., numerous but imperfect plant remains[2] were found.

[1] The geology of the region in which these beds occur has been subjected to detailed study by Prof. A. C. Lawson, with the collaboration in part of Dr. Chas. Palache, and a monograph on the Pliocene rocks by these geologists is shortly to appear.

[2] These plant remains, though imperfect, could, in part, be determined by an expert in the palæobotany of the Coast Range Tertiaries. They may at some future time be of value in correlating the Pliocene of Berkeley with the more fossiliferous and better known Pliocene around Mt. Diablo. The latter contains, aside from a rich marine fauna, abundant plant material, which has been partially worked up.

The rodent remains, consisting of the greater portion of a skull with the upper molars and incisors, were imbedded in a stratum of hardened clay immediately below the lignite.

Dr. Charles Palache was directly instrumental in the discovery of the skull, as the writer's first visit to the fresh-water beds was made under his guidance.

History of the Castoridæ

The beaver family reached its maximum development, in point of number of genera and species, in the middle Tertiary, and is represented at the present time by a single genus and species, *Castor fiber*, the beaver. The oldest representatives of the family known are found in the Lower Miocene, three species of the genus *Steneofiber* occurring at that horizon in America and one in Europe. This genus became extinct in the Middle Miocene of North America, but continues into the Upper Miocene and possibly Pliocene, *Steneofiber* (*Chalicomys*) *sigmodus* of Europe.

In the uppermost Miocene or lowest Pliocene (Loup Fork Beds) of North America two new genera, *Eucastor* and *Mylagaulus*, appear, representing new types of beaver, in which reduction in the number of molars has taken place. These types seem to have at least a distant relative in *Steneofiber* (*Chalicomys*) *sigmodus* of the European Pliocene.

The modern beaver, *Castor*, appears in the upper Pliocene of Europe and America, being accompanied in Europe by the genus *Trogontherium*, the largest representative of the family. *Castor* continues through the post-Pliocene up to the recent period, but its relative *Trogontherium* became extinct in the Quaternary. *Castor fiber* was formerly abundant in Europe and North America; it has, however, within comparatively recent times, suffered destruction through human agency to such an extent that its extinction is probably not far distant. In North America it was at one time found over the greater portion of the continent from northern Mexico as far north as the forest limit. It is now confined to the sparsely inhabited and less frequented districts. In Europe the present geographical distribution of the beaver is limited to a single locality on the river Elbe.

Most of the ancient Castoridæ were much smaller than the living form, averaging about half its size. The single exception is found in *Trogontherium*, which was somewhat larger than *Castor*.

In the following description, and in the discussion of affinities, it will be seen that the Californian Pliocene form bears an interesting relation to those from the Upper Miocene and the Pliocene of other portions of North America and Europe.

DESCRIPTION

Sigmogomphius Le Contei.[3]—*Gen. et sp. nov.* The posterior portion of the skull was unfortunately so decomposed and undistinguishable from the black, clayey matrix that in preparation only about one-half of the upper and two-thirds of the lower side could be made out. Evidently the greater portion of the skull was there originally, since the tympanic bullæ and other parts of the posterior end were present. The lower jaw could not be found.
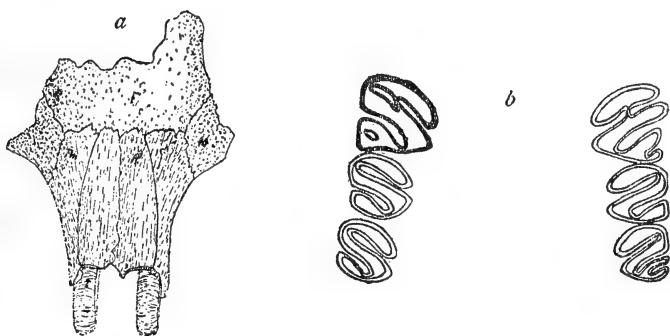
Fig. 1. *Sigmogomphius Le Contei.* *a*, Skull, seen from above (natural size). F, frontal; N, nasal; Pm, premaxillary; M, maxillary; I, incisor. *b*, right and left superior molar series (twice natural size). Right premolar shown in section (heavy line) a short distance above the triturating surface.

The anterior half of the cranium, of which the superior aspect is shown in Fig. 1, *a*, resembles very much that of *Castor*, or perhaps still more the proportions of the bones in *Steneofiber*. The nasal region resembles that of the other Castoroid forms. The incisors are rather close to the upper molars. On the lower side the anterior palatine foramina appear to be largely, perhaps entirely, in the premaxillaries, but run back to the suture between maxillary and premaxillary.

The superior molar series Fig. 1, *b*, consisting of three semiprismatic teeth on each side, converge anteriorly as in most Castoridæ. As the number of molars is one of the important characters of the genus, it should perhaps be stated that, although the head bones

[3] Named for Prof. Joseph Le Conte.

extend backward beyond the molars, no sign of a fourth tooth could be found on either side. The striking resemblance of the molars to those of *Eucastor*, Leidy, Fig. 2, *a*, which possibly possessed only three superior molar teeth, makes it appear the more probable that the fourth tooth was absent in *Sigmogomphius*. The molars were semi-hypselodont or semi-prismatic and strongly curved. They attained about half the size of those in *Castor fiber*, averaging near 11.5 mm. long; crowns, 4.8 mm. transversely, 4.5 mm. antero-posteriorly. Evidently they were not rooted till late in life, beginning to close up on the outer posterior corners, at which place a small lateral root was formed, the main portion continuing to grow for some time after this separation. The crowns of the premolars were larger than those of the molars, being about one-fourth longer and broader. Molars one and two were of nearly equal size. The triturating surface of the premolars is nearly triangular in outline; that of the molars is more nearly quadrate. All are set obliquely in the jaw, so that the folds of the enamel wall do not cut the fore-and-aft axis of the tooth at right angles, but obliquely.

The inner wall of all the molar teeth is thrown into a single strong fold, which, in the first tooth, traverses half the breadth of the crown to meet a similar fold from the opposite side. In the second and third it crosses the triturating surface, touching or almost touching the exterior wall. The presence of the fold is marked on the inner side of the tooth by a strong, sharp groove reaching almost to the end of the larger root.

On the outer side one, two, or three folds may be present. The premolars have three, the first molar one, and the second molar in the right series one, in the left series two. Of the three folds present in the premolar the middle one is the strongest, reaching across the tooth to the inner wall. The anterior outer fold comes in contact with the inner loop about the middle of the triturating surface, and shows a decided thinning of the wall at the point of contact, so that the two folds have almost united to form a transverse lamella. The third, or posterior fold, occurring in the premolars and the second molar of the left side, is small but distinct. On molars one and two the large exterior fold present corresponds to the middle one of the premolar. In these two there seems to be nothing corresponding to the anterior outer fold of the premolar. In Fig. 1, *b*, the first molar tooth of the right side is shown in transverse section, one-fourth of the distance from the lower end. Here

the anterior outer fold is seen to be an island, while the wall between it and the end of the inner fold is very thin. It seems possible that the island could unite with the distal end of the inner fold, giving it the length found in molars 1 and 2. The upper incisors, Fig. 1, *a*, were both present and differ little, if at all, from those of *Castor* or *Eucastor*.

COMPARISON WITH OTHER CASTOROID GENERA

In comparing this specimen with the other genera of the Castoridæ, there is little in the bones of the skull, which have been found, to show its relations, though the palatal and nasal regions are rather more like *Steneofiber* than *Castor*. Characters of great comparative value are, however, found in the highly developed molars. The number of molar teeth, three, is evidently important, since the normal number for the Castoridæ is four. In *Mylagaulus*, Cope, there is an exception, reduction to three or two having taken place. In *Eucastor tortus*, Leidy, described from beds of nearly the same age as the Berkeley Pliocene, there is found, perhaps, another exception. The specimen figured by Leidy,[4] Fig. 2, *a*, shows only three molars on each side, and in his description no reference is made to a fourth. The figure shows what is perhaps an alveole for a fourth tooth on the right side, but no mention is made of it in the text. The great reduction in size of the posterior molars would lead one to suppose that the third molar had disappeared in *Eucastor*. It is, however, true that in *Trogontherium*, Fig. 2, *c*, in which molars 1 and 2 are also much smaller than the premolar, a third molar, larger and more complex than the others, is present.

In number and arrangement of the enamel folds *Sigmogomphius* differs from *Castor* and *Steneofiber*, but approximates the characters in *Eucastor* and *Trogontherium*. In the first two genera there are always two or more enamel folds in the outer wall of the superior molars; in *Eucastor*, *Trogontherium*, and *Sigmogomphius*, the normal number for molars 1 and 2 is one. Both outer and inner folds are more oblique in these three forms than in *Castor* and *Steneofiber*.

Compared more particularly, Fig. 2, with *Trogontherium* and *Eucastor*, which are evidently its nearest relatives, *Sigmogomphius* differs from the first in having three molar teeth instead of

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[4] Extinct Mammals of Dakota and Nebraska, Pl. XXVI, Fig. 21.

four, in the more nearly quadrate form of molars 1 and 2, and in the open character of the folds, those of *Trogontherium* being in part closed up, forming islands. From *Eucastor* it differs again in possessing open folds, instead of the islands so characteristic of that genus. From both it differs in the relatively greater size of the molars. In *Trogontherium* and *Eucastor* the triturating surface of the premolar is nearly as long as that of molars 1 and 2 together, while in *Sigmogomphius* the length of the premolar as compared with that of molars 1 and 2 combined is about as one to one and a half.
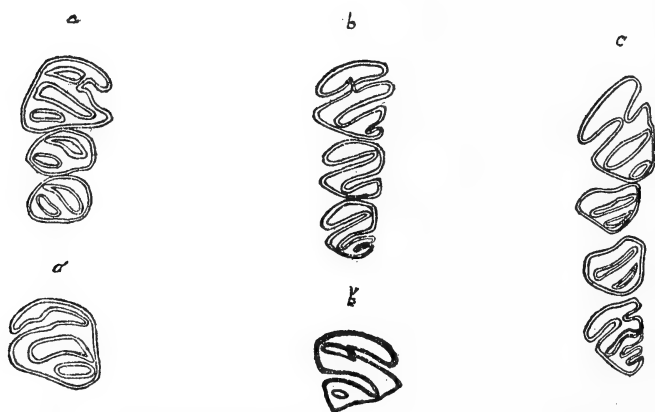
Fig. 2.   *a*, Upper molar series, right side, of *Eucastor tortus*; *a* , left, upper premolar of the same (*a* and *a'* twice natural size), after Leidy. *b*, upper molar series, left side, of *Sigmogomphius Le Contei*; *b'*, section of right upper premolar, cut a short distance above the triturating surface (*b* and *b'* twice natural size); *c*, left superior molar series of *Trogontherium Cuvieri*[5] (natural size), after Newton.

From the above comparison it appears that the new form is more closely related to *Eucastor* and *Trogontherium* than to any other forms; also that the differences between it and these genera are too great to permit its reference to either one.

Geological and Geographical Distribution of the Castoridæ

In the following table, giving the geological distribution of most of the known Castoroid species, the American Castoridæ seem to reach their maximum development at or before the beginning of

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[5] This figure was copied from an illustration, in which the enamel folds were indistinctly shown on the outer, right side. It was therefore impossible, in some cases, to tell whether the loops were closed or open at the outer end.

Pliocene time. If the culmination of the group in Eurasia can be definitely located at all, it would seem to occur in the Pliocene, or somewhat later than in America. This seems the more probable, as the genus *Steneofiber* lived longer in Europe than in America, while of the three related genera, *Eucastor*, *Sigmogomphius*, and *Trogontherium*, the American forms became extinct long before the European.

The apparent earlier culmination of the American Castoridæ, together with the earlier extinction of certain forms in this country, seem to point toward the American rather than the European origin of the family.

		EURASIA	NORTH AMERICA
RECENT		*Castor fiber* var. *fiber*	*Castor fiber* var. *canadensis*
QUATERNARY		*Castor fiber* var. *fiber* *Trogontherium Cuvieri*	*Castor fiber* var. *canadensis*
PLIOCENE	Upper	*Castor issiodorensis* *Trogontherium Cuvieri*	*Castor fiber* var. *canadensis*
PLIOCENE	Lower	*Steneofiber (Chalicomys) sigmodus* *Castor pelicedens* (?) *Castor Rosinæ* (?)	*Sigmogomphius Le Contei* *Eucastor tortus* *Mylagaulus monodon* *Mylagaulus sesquipedalis*
MIOCENE	Upper	*Steneofiber Jægeri*	
MIOCENE	Middle	*Steneofiber Jægeri* *Steneofiber minutus*	*Steneofiber montanus* *Steneofiber gradatus*
MIOCENE	Lower	*Steneofiber eseri*	*Steneofiber nebrascensis* *Steneofiber peninsulatus* *Steneofiber pansus*
EOCENE			

Geological Laboratory,
    University of California, February, 1896

GROUND SLOTHS IN THE CALIFORNIA QUATERNARY

AMONG the vertebrate fossils which have been brought to light in middle California within the past year there are two specimens which are of more than ordinary interest, as they indicate the existence of that peculiar group of mammals known as ground sloths in this region, within comparatively recent times. The first of these specimens to become known was a large humerus, received by the writer for determination from Mr A. Huff, who had found it near Hamlet station, on the east side of Tomales bay. In August last the writer visited Hamlet in order to determine if possible the exact occurrence of the humerus, but was not able to do so, owing to the absence of Mr Huff. Two months later Mr F. C. Calkins visited the locality at the writer's request and examined the spot from which the humerus was taken. To Mr Calkins I am indebted for the exact data relating to its occurrence.

The place pointed out to Mr Calkins as that from which the humerus was obtained is in a small run about three-quarters of a mile southeast of Hamlet and about 100 feet above the level of the bay. The stream in the run has cut down quite sharply for about 12 feet into a loose, sandy clay at the spot where the specimen was obtained. Above this point it flows through or over deposits similar to those just mentioned, and over rocks of the Franciscan series, so that the specimen must be derived from one or the other of these formations. As the Franciscan rocks are of middle Mesozoic age and have suffered much disturbance, the only possible source of such a specimen as that which we have under consideration is the more recent deposit.

Incoherent, yellowish, sandy clays, similar to those just mentioned, form the most prominent feature of the geology along the east side of Tomales bay between Point Reyes station and Hamlet. In many places they form prominent seacliffs up to 40 feet in

height. They are everywhere unsolidified and frequently show horizontal stratification. Mr Calkins considers the beds in the stream cutting in which the humerus was found as an extension of this deposit up the slope of the hill. Judging from their incoherent nature and horizontal stratification, these beds are certainly much younger than the latest Pliocene in the region. Excepting the humerus, the only fossil obtained from them is a badly worn elephas tooth, which was picked up on the shore of Tomales bay near Point Reyes. This formation resembles the deposits along the shores of San Pablo and Suisun bays, in which a Quaternary fauna, both molluscan and mammalian, has been obtained by the writer. In this connection the preservation of the specimen is a noteworthy character, as the bone is absolutely intact and the original material unchanged. One might almost suppose it a product of the last half century.

Two edentate humeri, much resembling the specimen under consideration, have been described from western North America. The first specimen was discovered on the Willamette river, Oregon, in 1839, by Mr Ewing Young. In 1842 it was described and figured by H. C. Perkins.[1] The humerus and a large gravigrade tooth, associated with elephas and bos or bison remains, were found about 12 feet below the surface, presumably in a Quaternary deposit. This specimen was provisionally named *Orycterotherium oregonensis*, but was afterward referred to *Mylodon* by Sir Richard Owen.

The other specimen, together with a femur, was obtained by Marsh from Alameda county, California (locality unknown), and was described by him as the type of a new genus, *Morotherium*, species *gigas*. Marsh considered *Morotherium* most nearly related to *Megalonyx* and *Mylodon*, being distinguished from the former by the absence of a supra-condylar foramen in the humerus, and from the latter by the absence of a depression for the round ligament in the head of the femur.

Unfortunately in the type specimen of *Morotherium gigas* the only portion of the humerus preserved is the distal end, minus the outer and inner condyles, so that it is not possible to make a satisfactory comparison. To as much of it as is preserved, the Tomales bay specimen shows a strong resemblance. With the Willamette

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[1] Amer. Jour. Sci., vol. 42, p. 137.

river humerus, of which good outline drawings were given by Perkins, our specimen agrees perfectly, excepting in one particular. In Perkins' drawings the deltoid ridge shows a deep narrow notch near the lower end, which is not present in the Tomales bay specimen. In his article Perkins states that there are *remains* of a large protuberance on the outside of the humerus, a little more than half way down the body of the bone, so that the notch in the deltoid ridge is possibly an irregularity in the weathered or broken bone. In the figures of the humerus of *Mylodon* which the writer has seen no such notch appears. The two specimens are of nearly the same dimensions throughout. The principal difference is in the length, the Willamette specimen measuring about 20, the other $18\frac{1}{2}$ inches long. The humerus of *Morotherium gigas* is about the same size as the other two specimens.

It is not improbable that the Willamette mylodon, *Morotherium gigas*, and the Tomales bay form are all of the same genus, possibly of the same species. Possibly they are all *Mylodon*, but since the humerus is not well preserved in *Morotherium*, and the femur, on which that genus was based, is absent in the other two specimens, it is not possible at the present time to determine their relationships satisfactorily.

Though it is not fully apparent to the writer that the genus *Morotherium*, as defined by Marsh, stands on a perfectly firm foundation, that name will be applied to the Tomales bay specimen until further evidence can be obtained.

The second acquisition consists of fragments of humeri from near Martinez, Contra Costa county. They include a distal end, possibly also the proximal end, of a right humerus, presented to the University of California by Judge Jones, of Martinez. These fragments were obtained by him some years ago from a loose, horizontally stratified deposit along the shore of Suisun bay, east of the town. Associated with them were bones and teeth of elephas and of a large species of *Equus*. The fragment representing the distal end of the humerus shows the articular surfaces, the outer condyle, and the supinator ridge perfectly, but the inner condyle is missing. It very closely resembles the specimen from Tomales bay, but is possibly from a somewhat larger animal, in which the lower end of the deltoid ridge was a little less prominent than in that form.

Several miles west of Martinez, along the shore of San Pablo bay,

there are numerous occurrences of a deposit similar to that east of the town.   In these beds there have been found remains of elephas and bison (?), along with a marine fauna, consisting of recent species, so that there can be no doubt as to the Quaternary age of the deposit.   The beds at Tomales bay evidently belong to the same epoch as those of San Pablo and Suisun bays.   It is probable that the other Mylodon-like remains from this coast, including the footprints at Carson, Nevada, also belong to the Quaternary.

Right humerus of *Morotherium gigas* Marsh
(A little less than one-fourth natural size)

ON THE OCCURRENCE OF GROUND-SLOTHS IN THE QUATERNARY OF MIDDLE CALIFORNIA

On the occurrence of ground-sloths in the Quaternary of Middle California. By JOHN C. MERRIAM, Berkeley.

The remains of two ground-sloths have recently been obtained from Middle Californian deposits of unquestioned Quaternary age. The first specimens found consisted of large humerus fragments obtained by Judge Jones, of Martinez, Calif., on the south shore of Suisun Bay. Associated with them were remains of *Elephas* and a large species of *Equus*. During the past year, 1899, Mr. A. Huff obtained a large and perfectly preserved humerus from loose, horizontally stratified deposits on the eastern shore of Tomales Bay, in Marin County, Calif. An *Elephas* tooth seems to have been obtained from the same deposit.

The specimens from the two localities seem to belong to the same or closely related species. This form fits most satisfactorily into Marsh's genus *Morotherium*, which was described from material obtained in Alameda County, Calif.

THE PLIOCENE AND QUATERNARY CANIDAE OF THE GREAT VALLEY OF CALIFORNIA

CONTENTS

INTRODUCTION

U P TO the present time only two representatives of the Canidae have been known to occur in the Tertiary and Quaternary formations of California. One of these is supposed to have been found in Quaternary gravels at Murphys, Calaveras County, and has been referred by Leidy to an existing coyote, *Canis latrans* Say. The second species was obtained from loose gravels near Livermore Valley, Alameda County. It was represented by a lower jaw which Leidy identified as *Canis indianensis*, a form described by him previously from remains discovered in the Ohio Valley. Unfortunately, the Californian type has disappeared and we have only Leidy's figure for comparison.

Of the three specimens described in this paper, two were presented to the University of California some years ago.   Shortly after they were received, the descriptions and figures published here were prepared by the writer.   They were withheld from publication as the specimens were found to represent new and very peculiar types, a thorough understanding of which would necessitate the acquisition of additional material.   During the eight years that have passed since these specimens were first studied, extended investigations of the gravels have been made but no new material has been discovered.   As yet no very productive beds have been discovered in the fresh water Tertiary and Quaternary of California and the number of mammalian specimens found is small.   It is to be hoped that somewhere in the extensive areas covered by these deposits in this state specimens may yet be discovered which will show other portions of the skeletons of these peculiar forms.

A third specimen discussed here is referred to Leidy's *Canis indianensis*, already described from this state.   It is, however, of considerable importance.   Since the loss of the jaw from Alameda County, it is the sole representative of the species known from this region.   This specimen is in the museum of the California Academy of Sciences.   Through the kindness of Mr. L. M. Loomis, director of the museum, and of Mr. F. M. Anderson, in charge of the palaeontological collections, the writer has been accorded the privilege of describing and figuring it here.

HYAENOGNATHUS PACHYODON n. gen. and sp.

PL. 28, FIGS. 1 AND 2

Generic characters.—Mandible short and massive. Alveolar margins greatly flared below $\overline{P3}$ and $\overline{P4}$.   Dentition $\overline{3}$, $\overline{1}$, $\overline{3}$, $\overline{3}$. $\overline{P2}$ and $\overline{P3}$ small. $\overline{P3}$ molariform. $\overline{P4}$ very large, conical, without accessory tubercles. $\overline{M1}$ massive; protoconid and paraconid forming a heavy shear, metaconid absent; heel short, with reduced hypoconid and entoconid. $\overline{M2}$ and $\overline{M3}$ small.

Occurrence.—The type specimen of this species consists of a mandible (No. M8139, Univ. Calif. Palaeont. Mus.) found at Asphalto, Kern County, close to the foot of the Temblor Range.   It was presented to the University by Mr. Bernard Bienenfeld of San Francisco.

The excavations at the locality where the jaw was found seem to have been in beds ranging from late Miocene to Quaternary, but principally in the latest formation. A jaw of a large species of *Smilodon* associated with the *Hyaenognathus* mandible indicates that it was probably obtained from a Quaternary bed, or possibly from the late Pliocene.

Mandible.—The lower jaw is short and heavy, having a strong resemblance to that of the hyaena. Below the molars its height and thickness are about equal to that in the hyaena, but the anterior portion below the premolars is somewhat higher and heavier. As in the hyaena, the inferior border of the mandible is strongly convex below the posterior end of the molar series.

Owing to the extreme shortness of the jaw, the alveolar margins are strongly flared below the carnassial and the last two premolars. The extent of this spreading possibly exceeded that in the hyaenas.

Dentition.—The dentition contains a most remarkable mixture of primitive characters with some extreme specializations. The formula $\overline{3}, \overline{1}, \overline{3}, \overline{3}$, shows the loss of but a single tooth, $\overline{P1}$, while the efficient portion of the dentition may be said to consist of but three teeth, a fairly developed canine, a powerful $\overline{P4}$ and a still heavier $\overline{M1}$.

The incisors are missing from both rami but the clearly defined alveoli show that they were small and crowded. $\overline{I1}$ and $\overline{I2}$ were near the size of the corresponding teeth in the hyaena but $\overline{I3}$ was much more reduced.

The lower canines are short and stout and appear a little weaker than in the hyaenas.

Of the three premolars, $\overline{P2}$ has been lost but its alveolus shows it to have been a thick, single-rooted tooth somewhat smaller than the one behind it. The root of $\overline{P3}$ exhibits a deep groove near the top and was probably divided toward the lower end. The molariform crown seems to be somewhat worn but the button-like base is very thick, with a transverse diameter almost equalling the longitudinal. $\overline{P4}$ has nearly two and one half times the antero-posterior extent of $\overline{P3}$. The simple cone of the crown has no anterior or posterior accessory tubercles, although there is a shelf on the cingulum at the posterior inner angle. On both rami the crown of this tooth is bent backward slightly and is very close to the anterior blade of the carnassial.

In the molar series, $M\overline{1}$ is exceedingly massive and with $P\overline{4}$ has done practically all of the work falling to the cheek teeth. The protoconid and paraconid are both greatly developed. No trace of a metaconid is discovered, although the postero-internal ridge of the protocone is prominent. The small talonid supports an external and an internal tubercle, both of which are very small and low. The crown of $M\overline{2}$ bears an anterior and a posterior tubercle, of which that representing the talonid is much the smaller. $M\overline{3}$ is represented by a small alveolus on each ramus.

Affinities.—The dentition of *Hyaenognathus* has a striking resemblance to so much as is known of the problematical genus *Borophagus*, described from a jaw fragment found in the Blanco beds of Texas. For comparison Cope's figures[1] of the type specimen are reproduced here together with outlines of the corresponding portion of the *Hyaenognathus* jaw (figs. 1, 2, 3, 4, 5). The only other specimens referred to *Borophagus* are an inferior premolar with a conic basal cusp and a single blade of a sectorial, which were thought by Cope to belong here. If the premolar with a conic basal cusp belongs to *Borophagus*, the Californian form could not be closely related to this genus. If this is eliminated as doubtful and a comparison made with the type, we find the two forms possessing a combination of characters not found elsewhere. Both have the reduced $P\overline{2}$, depressed $P\overline{3}$, and the greatly enlarged, simple $P\overline{4}$. Cope's restorations of $P\overline{4}$ in fig. 2 and fig. 4 show the posterior basal lobe of this tooth considerably extended. According to his view of the tooth in fig. 5, this restoration is not justified, as the outer portion of the heel was unbroken. On fig. 4 the writer has indicated in an unbroken line a third suggestion as to probable form, beginning the restoration at the point *a* where the break in the heel occurs. This shows the tooth to have a form somewhat similar to that of $P\overline{4}$ in *Hyaenognathus*, although not so broad. Cope classified *Borophagus* on the assumption that it had four inferior premolars, though he suggests doubt of this at one point in his description. This is, however, improbable, as the presence of a $P\overline{4}$ corresponding in size to what he considered as the large $P\overline{3}$ and accompanied by a heavy sectorial would mean the elimination of $P\overline{1}$, just as has occurred in *Hyaenognathus* and in the hyaenas.

[1] Geol. Surv. Texas, 4th Ann. Rep., 1892. Vert. Palaeont. Llano Estac. p. 52, Pl. XIII figs. 4, 4*a*, 4*b*.

Hyaenognathus is evidently allied to *Borophagus* and it is not impossible that future investigation may show generic identity. The differences in the minor details of form in the premolars indicate, however, that the types are specifically quite widely separated, *Hyaenognathus* being the more specialized. Several facts suggest that, while we may show that the two forms are clearly related, we are not in a position to demonstrate generic identity. The Californian specimen represents a more extreme form coming probably from Quaternary beds, while *Borophagus* is Pliocene; the two
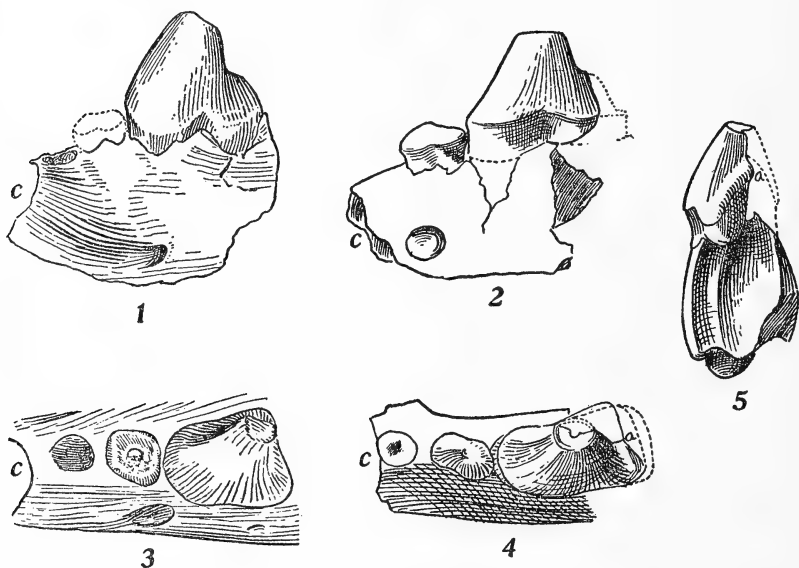
Figs. 1 and 3. *Hyaenognathus pachyodon*, × ¾. *c*, alveolus of canine.
Figs. 2, 4 and 5. *Borophagus diversidens* Cope, × ¾. *c*, alveolus of canine. *a*, point on P4̄ where fracture begins. (After Cope.)

occur at localities geographically distant from each other; and we do not know the most essential parts of the structure of *Borophagus*.

The genus *Borophagus* was referred provisionally to the Hyaenidae by Cope, and the general form of the mandible in *Hyaenognathus* reminds one very much of that family. The dentition of *Hyaenognathus* has, however, no real structural resemblance to that of the hyaenas, though its functions were evidently similar. This genus represents a type analogous to the hyaenas, but is derived from a different source and worked out on a very different type of tooth

structure.   It represents the extreme of known specialization of the dog family in one direction.

The genus differs so far from any known form that its affinities are not clearly shown.   It resembles the Amphicyonine canids in the heavy jaw and simple premolars, but differs greatly in the characters of the tubercular molars and of the heel of $\overline{M1}$.   Also, $\overline{P4}$, although simple, does not correspond to any form found in the Amphicyonines.   The genus *Cephalogale*, a somewhat primitive form referred by Zittel to the Simocyoninae, presents many points of resemblance, though it is separated by differences of the same nature as those just mentioned.   A similarity to the Mustelines of the *Gulo* group is presumably only superficial.

Professor Cope evidently judged *Borophagus* to be derived from the peculiar aberrant Aelurodons of America.   They resemble *Hyaenognathus* in possessing heavy jaws and heavy premolars, in the reduction of the tubercular molars, and in the reduced talon and metaconid of $\overline{M1}$.   There are, however, four premolars in *Aelurodon*, three of these having accessory cusps, and the degree of modification required to produce from them a premolar dentition like that of *Hyaenognathus* would be very considerable.

The true affinities of this form can be determined with satisfaction only when we know more of the dentition and when we have some acquaintance with the limb structure.   Some of the characters suggest a distant relationship to the Amphicyonines, though this is indistinct and a very wide gap must be filled before we can prove that the actual ancestors are to be found in that group.   We can feel assured that in whatever division it is finally shown to belong, its place will be near the outer border of the group.

MEASUREMENTS

Length of mandible from anterior end of symphysis to posterior end of $\overline{M2}$.. 112 mm.
Height of jaw below protoconid of $\overline{M1}$.............................. 38
Greatest thickness of ramus below protocqnid of $\overline{M1}$................... 20
Length of premolar series... 41
   "   " molar series... 48
Greatest diameter of base of canine................................. 16
Antero-posterior diameter of $\overline{P3}$.................................... 10
   "   "   "   " $\overline{P4}$.................................... 22
   "   "   "   " $\overline{M1}$.................................... 30.5
   "   "   "   " $\overline{M2}$.................................... 10

Transverse diameter of P$\overline{3}$ .... .8.5 mm.
      "   "   " P$\overline{4}$... 17
      "   "   " M$\overline{1}$... 16
      "   "   " M$\overline{2}$... 8.5

HYAENOGNATHUS? (PORTHOCYON n. gen.?) DUBIUS n. sp.

PL. 29 AND PL. 30, FIG. 1

Distinctive characters.—Muzzle short, forehead and sagittal crest high. Brain case small and narrow, outer walls sloping sharply from the crest. Wings of the premaxillaries reaching back to the blunt anterior ends of the frontals. Palate very broad, with two pairs of large posterior palatine foramina. Posterior nasal openings not reaching forward to the end of the molar series. Dentition $\underline{3}$?, $\underline{1}$, $\underline{4}$, $\underline{2}$. I3 very large. Premolars crowded. Sectorial massive, without deuterocone. Metacone and heel of M$\underline{1}$ small. M$\underline{2}$ reduced.

Occurrence.—This form is represented by a single specimen consisting of the greater portion of a cranium with the essential parts of the dentition (No. M8138, Univ. Calif. Palaeont. Mus.). It was found in a quarry about two miles southeast of Cornwall, Contra Costa County, California, and was presented to the University by Mr. Bromley of Oakland.

At the request of the writer, the beds in which the cranium was found have been examined by Mr. V. C. Osmont, with a view to determining their age. The formation was found to consist mainly of rather loose gravel beds with some sand and clay. As a whole, it resembles the Quaternary near Suisun Bay just north of this exposure. The beds rest upon the San Pablo formation and dip 10°–20° to the north. Mr. Osmont believes that this formation is cut by Quaternary terraces and that, owing to the terracing and deformation which it has suffered, it may be necessary to refer it to a late Pliocene epoch rather than to the Quaternary.

Cranium.—The cranium is that of an animal between a large wolf and a hyaena in size and resembling the latter in possessing a greatly abbreviated facial region. The results of this shortening are most noticeable in the inferior view (Pl. 30, fig. 1) where the diameter of the palate between the blades of the carnassials is seen to equal the length from the canine to the posterior end of M$\underline{2}$. In the lateral view (Pl. 29) the forehead appears very high and full, although the head shows no indications of deformation by crushing. The brain

case is very narrow and the walls slope abruptly from what has evidently been a high and sharp crest. Unfortunately the whole of the upper portion of the skull is gone and the exact form of the crest can not be determined.

The nasal region exhibits a characteristic structure. The posterior ends of the nasals and the anterior ends of the frontals enclosing them are broad and blunt, while the posterior wings of the premaxillaries extend backward almost to the posterior ends of the nasals and meet the frontals.

The anterior end of the jugal did not extend to the lachrymal foramen as in *Canis*, but ends considerably below it as in the hyaena.

In the palatine region there is again a resemblance to the hyaena, in that the posterior nasal opening does not reach forward to the end of the molar series.

In the foramina of the skull a distinctive mark is found in the presence of the two pairs of large posterior palatine foramina.

Dentition.—The dentition is essentially canid. I$\underline{1}$ and I$\underline{2}$ have been lost but were evidently quite small, as there is but little space for them between I$\underline{3}$ and the median premaxillary suture. I$\underline{3}$ is very large and in this respect resembles the hyaenas and some of the Aelurodons. The canines are not large. They tend rather to be smaller than is common in the Canidae. P$\underline{1}$, $\underline{2}$ and $\underline{3}$ have been lost but the alveoli show them to have been closely crowded. They were evidently small, though P$\underline{2}$ and P$\underline{3}$ were two-rooted. The carnassial is wide and heavy. The protocone blade is situated rather far forward. The deuterocone has disappeared, though the inner root is present. On M$\underline{1}$, the metacone is noticeably reduced, the heel and the whole inner lobe are small and the tubercles very low. The anterior inner angle is extended forward from the protocone forming a characteristic shoulder. M$\underline{2}$ is very considerably reduced.

Affinities.—The relation of this form to that represented by the type of the genus *Hyaenognathus* is a particularly interesting one. Each is represented by a single specimen and they are found in beds not differing widely in age. Both represent short-muzzled, broad-palated types of canids with dentitions which are specialized but still not greatly reduced numerically. Unfortunately we have no corresponding parts for comparison, so that the true relationships between the two can not be determined with absolute certainty. Some of the features of the dentition would seem at first to show that

they are very different.   In the superior dentition of *Porthocyon*, P$\underline{4}$, which opposed the anterior side of inferior P$\overline{4}$, is a small tooth not corresponding in size to the large P$\overline{4}$ of *Hyaenognathus*.   Also, the greatest width across the mandible of *Hyaenognathus* is across P$\overline{4}$, or some distance in front of the carnassial, while in *Porthocyon* the width of the palate is greatly decreased immediately in front of the carnassial.   On the other hand, we find that in the hyaena, in which somewhat similar structures occur, the large P$\overline{3}$ standing at the point of extreme flare of the mandible is opposite the point where contraction of the palate begins and strikes either against or outside the posterior portion of a small P$\underline{2}$.   In *Porthocyon* P$\underline{3}$ is moved so far inward that it stands in front of the inner root of the carnassial, and it may have had much the same relation to P$\overline{4}$ in occlusion that we find between P$\underline{2}$ and P$\overline{3}$ in the hyaena.   This relation occurs at about the same point in the jaw as in the hyaena, but is farther forward in the dentition, owing to the greater antero-posterior extension of the premolars in the hyaena after the reduction of the molars.

In a comparison of the molar series with that of the mandible of *Hyaenognathus*, we find the reduced crushing surface of M$\underline{1}$ corresponding fairly well to the small low tubercles on the short talonid of the lower sectorial.   The presence of a prominent antero-internal angle on the first upper molar may be due to anterior extension following loss of the metaconid on the inferior sectorial.   The reduction of the metacone can be accounted for by the median position of the single anterior tubercle of M$\overline{2}$.   Finally, the more than ordinarily sharp upward twist of the posterior molar is suggestive of correspondence to the similar curve in the inferior molar series of *Hyaenognathus*.

The resemblances just mentioned, coupled with the fact that the two specimens represent individuals not far from the same size, suggest that we are dealing with forms closely related, if not identical.   This identity may not be specific, as the two probably do not belong to the same epoch and show a certain degree of difference in dimensions.   The writer inclines to the belief that the two forms are generically identical.   He doubts, however, whether it is possible to prove identity in the absence of corresponding parts, as characters might exist in either form without finding expression in the general correspondence discussed above.   This specimen is there-

fore given a provisional generic name by which it may be known until the discovery of associated upper and lower jaws gives definite evidence of its affinities.

As in the case of the mandible of *Hyaenognathus*, the form represented by this specimen is so different from any known type that its broader relationships are not clear.   While it is recognized as a typical canid, it has no close affinities with any well defined group. As in *Hyaenognathus*, any resemblance to the Amphicyons which appears in the premolars is practically invalidated by the extreme reduction of the molars.   There is here, again, some resemblance to certain of the Aelurodons (*A. saevus* and *A. wheelerianus*) in the form of I$\underline{3}$, and to a certain extent in the outlines of the upper molars.   Among the noticeable characters separating it from this group is the absence of the most distinctive feature of the upper dentition of *Aelurodon*, viz.: of the protostyle of P$\underline{4}$.

Some of the closest general similarities to any other group that this form shows are its resemblances to certain of the species of *Palaeocyon* (*Speothos*) described by Lund[2] from the Brasilian cave fauna.   *Palaeocyon* was a short-nosed, broad-palated dog with simple, crowded premolars and a very greatly reduced M$\underline{2}$.   M$\underline{1}$ was also small and the superior sectorial had no deuterocone.   This genus is distinguished from the Californian form by its relatively small I$\underline{3}$; minute M$\underline{2}$; narrower and structurally different crushing lobe of M$\underline{1}$; more slender facial region; and the absence of the peculiar characters of the nasal region, jugal, and posterior palatine foramina found in *H.*(?) *dubius*.   The two types are quite distinct and they may simply represent evolution in the same direction along two different lines.   *Palaeocyon* is evidently a member of the Icticyon group in which extreme reduction has taken place at the posterior end of the upper and lower molar series before great crowding or elimination occurred in the premolar series.   In the Californian form we have probably an older species.   It shows less of the special kind of molar reduction than we see in the Icticyons, but is in many ways more highly specialized.   If we consider the *Hyaenognathus* mandible as representing the same group as *H.*(?) *dubius*, we discover a farther resemblance to the Icticyons in the absence of the metaconid from M$\overline{1}$.   On the other hand the

[2] P. W. Lund.   Blik paa Brasiliens Dyreverden, 1841–45.

presence of three molars, the peculiar reduction of the premolars and the presence of two low tubercles on the heel of the sectorial show it to be distantly removed from *Palaeocyon*.

For the present we can not do more than consider this specimen as representing a very aberrant type of dog, considerably removed from any known group. As it belongs to a comparatively late epoch, we may hope to establish its relationship to one of the older and better known groups when we learn more of the Canidae of the West American Pliocene.

Should this form prove to be identical with *Hyaenognathus*, as has been suggested, we shall have made but little advance in the determination of the true affinities of that genus beyond what was suggested by the type specimen. The characters of the cranium and superior dentition seem to point out the same general position with relation to the other types of canids. This we may consider as evidence that the two specimens really represent the same group. It will be necessary to know something of the limb structure, as also something of the history of the group, before we shall have thoroughly satisfactory evidence concerning its true relationships.

MEASUREMENTS

Width of cranium between the most anterior points of orbits	65 mm.
Length of premolar series	55
" " molar series	23.5
Antero-posterior diameter of upper canine at alveolar margin of enamel	16
Antero-posterior diameter of alveolus of P$\underline{2}$	7
" " " " " " P$\underline{3}$	10
" " " " " P$\underline{4}$	28
" " " " " M$\underline{1}$	16
" " " " " M$\underline{2}$	9
Greatest transverse diameter of P$\underline{4}$	16
" " " " shear of P$\underline{4}$	13
" " " " M$\underline{1}$	22
" " " " M$\underline{2}$	13

CANIS INDIANENSIS Leidy

PL. 30, FIG. 2

Canis primaevus LEIDY. Proc. Philad. Acad. Nat. Sc. 1854, p. 200: Jour. Philad. Acad. Nat. Sc. 1856, III, p. 167, Pl. XVII, figs. 11–12; Pl. XXI, figs. 14–16.

Canis indianensis LEIDY. Jour. Philad. Acad. Nat. Sc. 1869, p. 368.

Canis indianensis LEIDY. Geo. Surv. Terrs. Vol. I, Foss. Vert. 1873, p. 23, Pl. XXXI, fig. 2.

Canis lupus. COPE AND WORTMAN. Indiana Geol. and Nat. Hist. Surv. 14th Annl. Rep. 1884, Part II, p. 9.

Canis indianensis. COPE. Jour. Philad. Acad. Nat. Sc., Ser. 2, Vol. IX, p. 453, Pl. XXI, figs. 14–16.

Occurrence.—The specimen referred to this species includes a part of an atlas and the anterior portion of the left ramus of a mandible with the canine, the sectorial, and the last premolar. It is embedded in coarse sand and gravel cemented by asphaltum. Associated with it is the anterior portion of a *Mylodon* skull containing the roots of the molars. The character of the matrix and the presence of *Mylodon* indicate the Quaternary age of the beds in which it was found.

The locality given for the jaw is Oil Springs, Oil Cañon, Tulare County. The writer has not been able to obtain any definite information concerning this place. There is an Oil Cañon a few miles north of Asphalto, Kern County, and an Oil Springs, Tar Cañon, in the western part of Kings County.

Relationships.—The dimensions of the jaw from Oil Springs are nearly the same as those of the mandible from near Livermore Valley referred to this species by Leidy. The form of the teeth can not be distinguished from that of Leidy's specimen. The jaw appears slightly heavier below the sectorial but the difference may be due to distortion of the fragmentary anterior portion. In both specimens $M\overline{1}$ has a well developed metaconid and the hypoconid is slightly compressed laterally.

This form is, so far as can be seen, a typical dog. It is considerably larger than any existing American wolf and has a more massive jaw and a heavier sectorial. The specific identity of the Californian form with Leidy's type from the Ohio Valley might possibly be called in question, as we do not know corresponding portions of the skeleton from the two regions. The discovery by Cope of a very large wolf similar to *C. indianensis* in collections from the Quaternary of Texas shows that the eastern species ranged well out toward California, and makes it easier to believe that the form from this state is really to be classed with it.

MEASUREMENTS

Height of jaw below protoconid of $M\overline{1}$................................. 42 mm.
"   "   "   "   anterior end of $P\overline{2}$............................... 35
Thickness of lower border of jaw below $M\overline{1}$.......................... 16.5

Length from posterior side of M$\overline{1}$ to anterior side of canine..............120   mm.
Antero-posterior diameter of M$\overline{1}$................................. 35
   "   "   "   " P$\overline{4}$................................. 17.5
   "   "   "   " canine................................ 13

CANIS LATRANS Say (?)

Canis latrans. Determined by Leidy. J. D. Whitney. Aurif. Grav. of Sierr. Nev. of Calif., Mem. Mus. Comp. Zool. Harvard, Vol. VI, No. 1, Part 1, p. 246.

A tibia probably obtained from Quaternary gravels at Murphys, California was referred to this species by Leidy. Some doubt exists as to the locality. On the basis of more modern classification of the coyotes, the specific determination might also be questioned.

University of California,
November, 1903

Hyaenognathus pachyodon n. gen. and sp.

Figures reproduced three-fourths natural size

Fig. 1.   Left ramus of mandible, outer side.
Fig. 2.   Mandible from above.
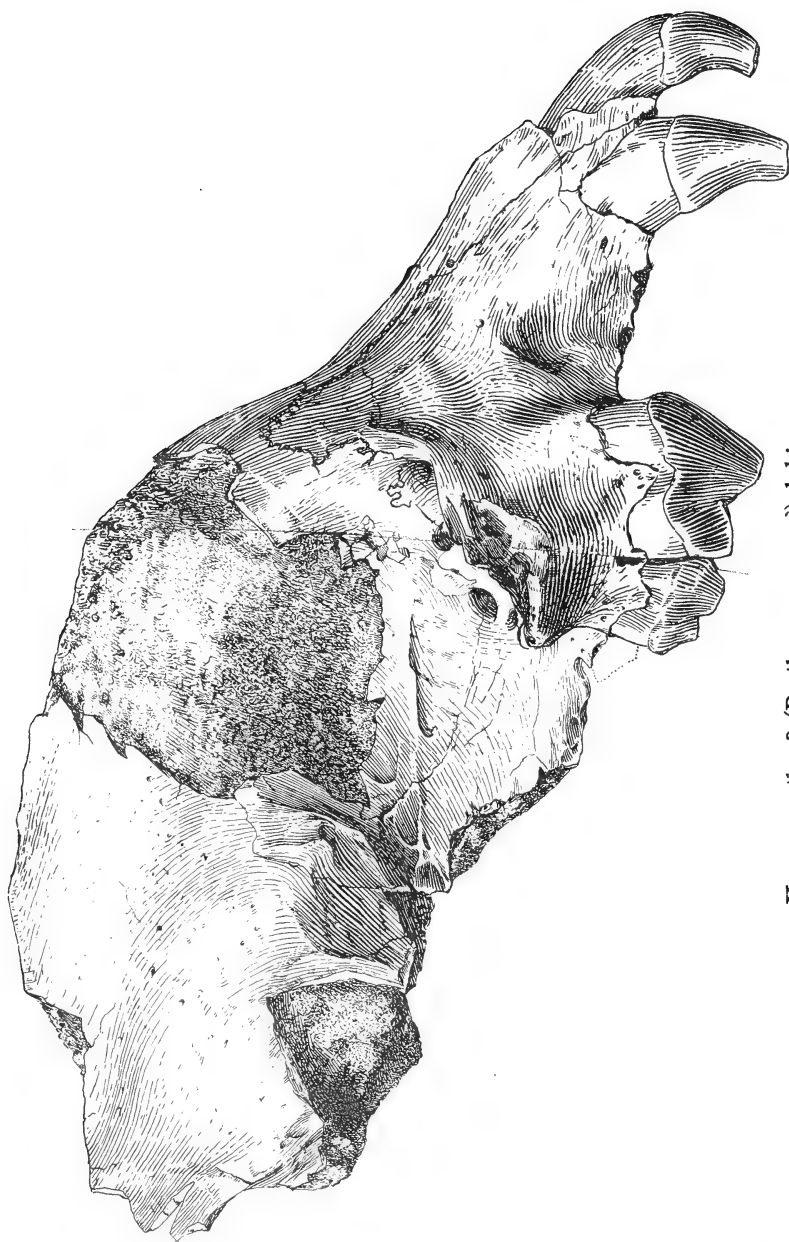
Hyaenognathus? (Porthocyon n. gen.?) dubius n. sp.

Figure reproduced three-fourths natural size

The cranium from the right side. The outline of M2 is shown by a dotted line.
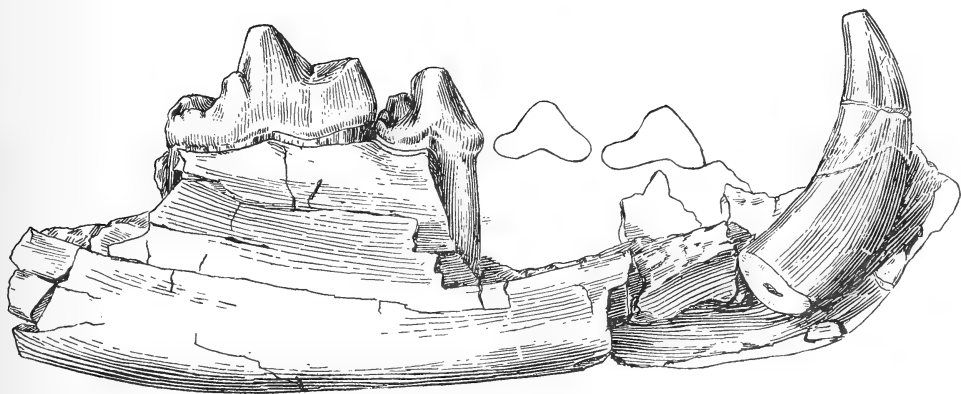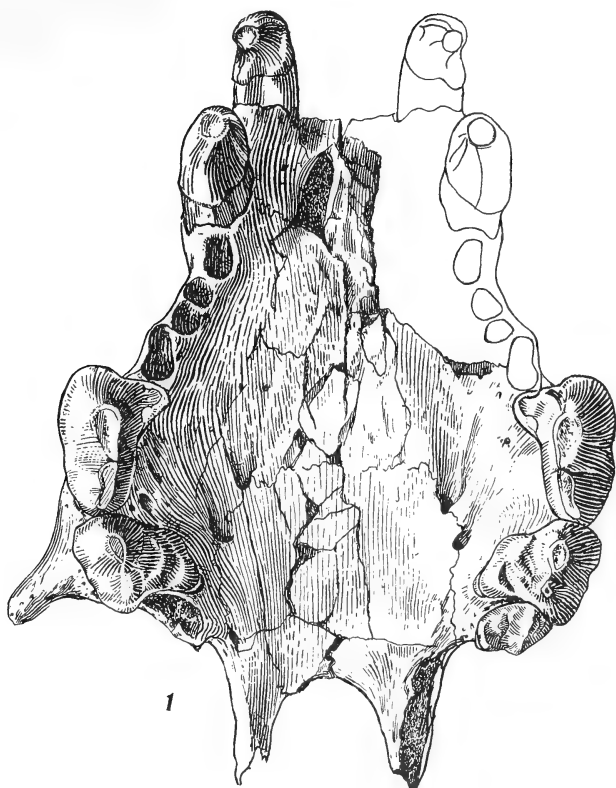
Figures reproduced three-fourths natural size

FIG. 1. **Hyaenognathus?** (**Porthocyon** n. gen.?) **dubius** n. sp.   Inferior side of the cranium.

FIG. 2. **Canis indianensis** Leidy.   Inner side of the left ramus of the mandible.   The partial outlines of P$\overline{2}$ and P$\overline{3}$ are drawn from impressions in the matrix.   The length of the jaw is slightly exaggerated.
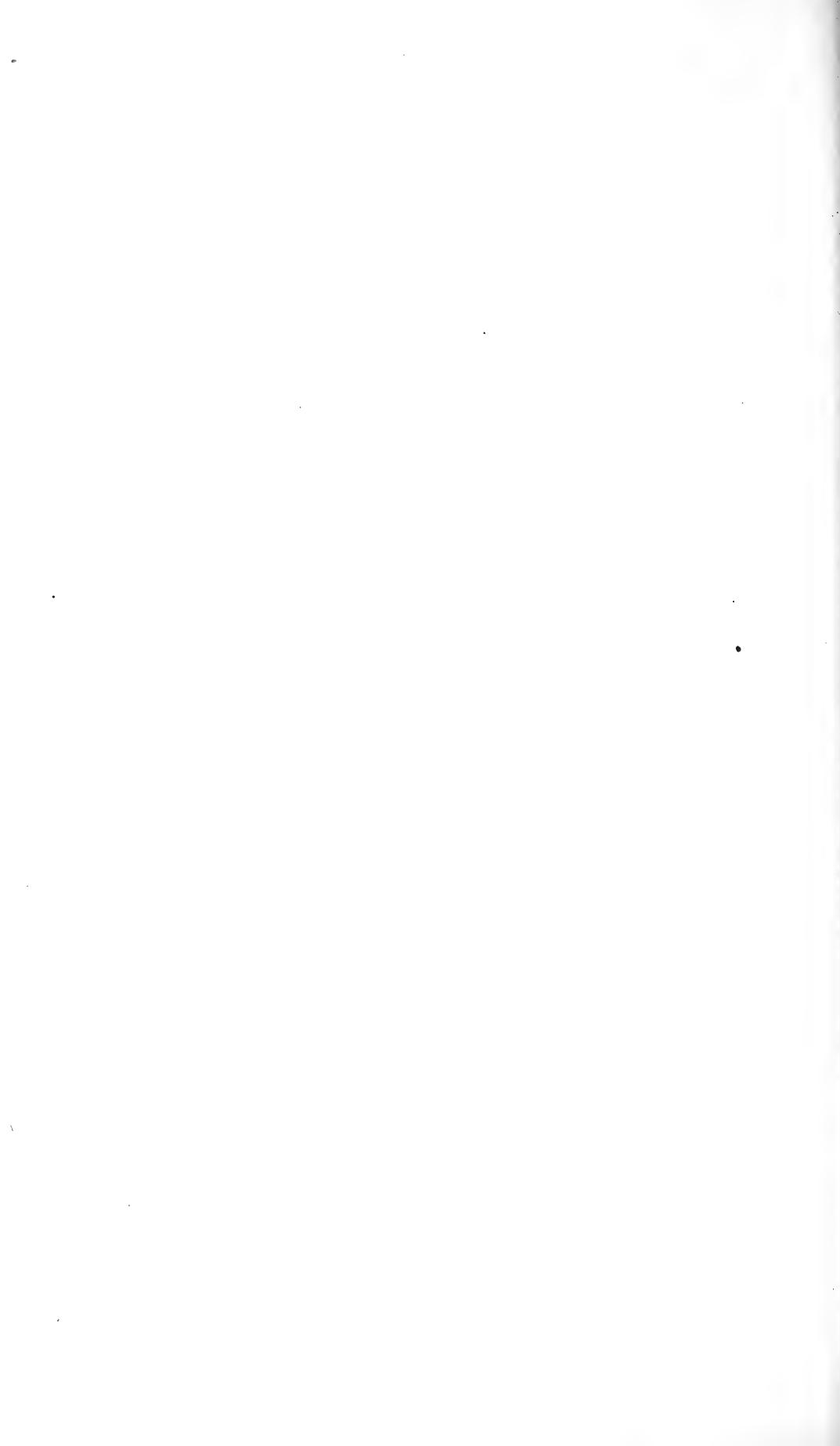
A NEW SABRE-TOOTH FROM CALIFORNIA

SOME years ago Mr. Bernard Bienenfeld of San Francisco very kindly presented to the University of California a collection of fossil mammalian remains containing at least two carnivores which are new to science. One of these has already been described as the type of a new and peculiar canid genus, *Hyaenognathus*.[1] The second form, which is described below, represents a large species of sabre-tooth differing considerably from those previously described.

MACHAERODUS (?) ISCHYRUS, n. sp.

TEXT, FIG. 1

The species is known only from a mandible (No. 8140 Univ. Calif. Palae. Col.) found with the type of *Hyaenognathus* near the foot of the Temblor range at Asphalto, Kern County. This specimen, like the others found with it, is covered with a very thin film of gypsum preserving the fragile bone.

The species is characterized by the great reduction of P_3, the presence of a single posterior cusp on P_4, the absence of both metaconid and heel from M_1, the shortness of the diastema, the possession of a prominent flange below the symphysial region, and the abbreviation and general robust character of the jaw.

The age of the beds in which the mandible was found is not definitely determined. Such stratigraphic and palaeontological evidence as has been obtained indicates Quaternary or late Pliocene age. In addition to this, the evidence furnished by the stage of evolution of this species and of the associated *Hyaenognathus* seems to show that they are probably not older than Pliocene.

The portion of the mandible present represents a large animal, and the species must have been one of the more formidable members of the sabre-tooth group. The jaw is noticeably heavy, while the inferior flange is wider and deeper than in the typical species of

[1] Bull. Dept. Geol. Univ. Calif., Vol. 3, No. 14, p. 278.

Smilodon and *Machaerodus* but hardly as prominent as in *Hoplophoneus*. In the symphysial region the inferior portion of the anterior face is concave on either side of the median line, but the whole upper part of this face is strongly convex, and the portion of the alveolar margin occupied by the incisors is bowed far forward. In the region of the cheek teeth the alveolar margins are flared outward rather more than is common in the cats, owing probably to shortness of the jaw.

The dentition is $\frac{3}{3}, \frac{1}{1}, \frac{2}{2}, \frac{1}{1}$. I_3 is absent from both rami, but its alveolus indicates the existence of a tooth approaching the canine in size. I_2 is considerably larger than I_1. P_3 is very small and is single-rooted. P_4 possesses a single large accessory cusp on either
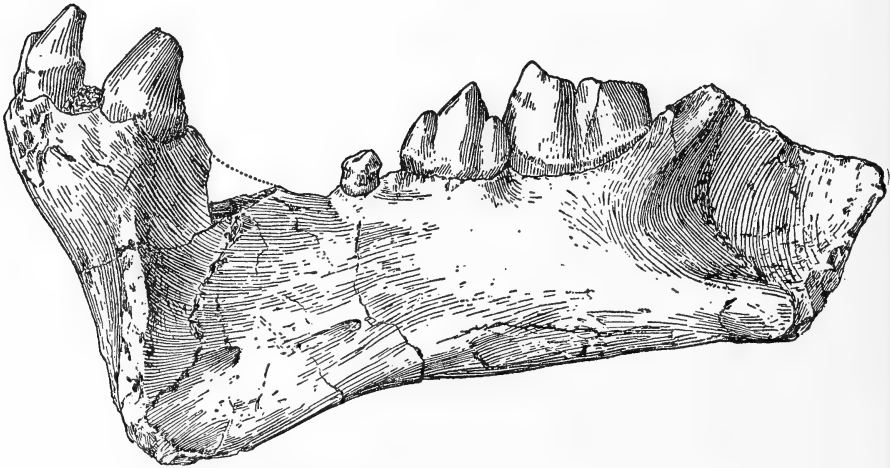
Fig. 1.   *Machaerodus* (?) *ischyrus*, n. sp.   About $\frac{2}{3}$ natural size.

side of the protoconid, but shows no trace of a posterior basal cusp. The protoconid stands almost erect. In M_1 the protoconid and paraconid are well developed and of nearly equal size. The posterior portion of M_1 is somewhat damaged, but there appears to have been neither metaconid nor heel present. The transverse diameter is relatively large and the tooth considerably heavier than in *Smilodon neogaeus*.

Of the North American species *Machaerodus gracilis* Cope, from the Port Kennedy Fissure, resembles the Californian species in the form of P_3, while the heel of M_1 has almost disappeared. *M. ischyrus* differs from this species particularly in the shortness of the diastema and probably of the whole jaw, in the absence of a pos-

terior basal cusp on P_4, and in the complete reduction of the heel of M_1. Judging from Cope's figure[2] of the type of *M. gracilis* the mandibular flange is not as prominent and the jaw as a whole somewhat weaker than in *M. ischyrus*.

Smilodon fatalis Leidy, from the Quaternary of Texas, known only from the dentition of the upper jaw, if a typical *Smilodon* as it appears to be, would differ in the structure of P_4, as also of the mandible in general.

Dinobastis serus Cope, from the Texas Quaternary, does not differ from *M. ischyrus* greatly in size and had large external incisors with a moderately elongated superior canine. The superior sectorial has a large protostyle, but the basal cusp anterior to this is rudimentary. This means that, as in *Hoplophoneus*, the posterior part of P_4 opposing it was probably relatively shorter than in *Smilodon*. The characters mentioned all suggest correlation with *M. ischyrus*, although there would at present be no justification for considering them identical.

Felis imperialis Leidy, from the Quaternary of Middle California, is known only from a fragment of the upper jaw with the third premolar. It is evidently also a short-faced form but seems to have been, as far as can be determined, of the true *Felis* type.

Machaerodus catocopis Cope, from the Loup Fork of Kansas, has a relatively larger inferior canine, a deeper mandibular flange, and is much narrower across the symphysis.

Machaerodus palaeindicus Bose, from the Siwalik beds of India, very closely resembles this species in size, in shortness of the diastema, and in the form of the anterior portion of the mandible. It appears from the figures[3] that P_4 has but a single posterior cusp. P_3 is, however, a heavy tooth apparently with two roots and differing much from the corresponding tooth in *M. ischyrus*.

Compared with the later machaerodont forms this species is relatively specialized in the reduction of P_3, and the apparent absence of both heel and metaconid from M_1. It is relatively primitive in lacking a second posterior cusp on P_4, and in the prominence of the mandibular flange, which is secondarily reduced in the later sabretooths. The abbreviation of the diastema, together with the flare

[2] E. D. Cope. Jour. Philad. Acad. Nat. Sc., 2nd Ser., Vol. 11, Pl. 20, fig. 1.
[3] R. Lydekker. Paleont. Indica, Ser. 10, Vol. 2, Pl. 43.

of the alveolar borders, and the robustness of the mandible show that this is a comparatively short-jawed type.

The combination of characters appearing here is peculiar. The stage of development of the mandibular flange suggests an advanced form of *Deinctis,* such as is seen in the John Day *Pogonodon,* or the more primitive *Hoplophoneus* species. The reduction seen in P_3 and in the posterior portion of M_1 equals or exceeds that in *Smilodon* and *Machaerodus.* The character of P_4 is that of *Hoplophoneus* rather than of the later sabre-tooths. As far as can be judged from the characters present, this species could not consistently be referred to any of the three machaerodont groups which it most nearly approaches, viz: *Hoplophoneus, Machaerodus* and *Smilodon.* It may represent a new subgeneric type, in which a peculiar set of conditions suggested by the shortness and strength of the jaw have made possible the combination of primitive and specialized characters seen here. A knowledge of the cranium may bring out definite relationship to one of the known groups, and I therefore refer to the species tentatively under the more or less comprehensive name of *Machaerodus.*

MEASUREMENTS

Length of mandible from anterior side of I_1 to posterior side of M_1 . . .	123	mm.
Length of mandible from anterior side of canine to posterior side of M_1 . .	107	
Width of anterior face of symphysial region.	52	
Depth of jaw across the middle of the flange.	58	
Depth of mandible below posterior end of P_4.	36	
Length of inferior diastema.	33.5	
Width of I_1 transversely.	4	
Width of I_2 transversely.	6.5	
Antero-posterior diameter of inferior canine.	14.5	
Antero-posterior diameter of P_3.	7	
Antero-posterior diameter of P_4.	20	
Antero-posterior diameter of M_1.	28.5	
Transverse diameter of M_1.	14.5	

ON THE OCCURRENCE OF DESMOSTYLUS, MARSH

THE genus *Desmostylus* was described by Marsh[1] in 1888 from tooth fragments found in Alameda County, California. It was referred to the Sirenia, and its nearest affinities were supposed to be with *Metaxytherium* from the Tertiary of Europe. In 1899 and 1900 additional specimens were examined by the writer, with a view to obtaining further information as to its affinities, but no material was obtained which furnished more evidence than the type specimens described by Marsh.

In 1902 Yoshiwara and Iwasiki[2] described from the Miocene of Japan a number of specimens showing tooth structure almost identical with that of *Desmostylus*. This material also furnished considerable evidence concerning the structure of the skull. The authors recognized the resemblances of this form to the Sirenia.

Shortly after the appearance of the paper on the Japanese specimens a review of this article was published by Professor H. F. Osborn,[3] who included a short note on recent studies of *Desmostylus* by Merriam. Professor Osborn considered the reference of the animal somewhat uncertain, very properly pointing out that both sirenian and proboscidean characters were represented.

During the past year two occurrences of *Desmostylus* have come to the notice of the writer. In both cases the reference of the specimens to this form seemed beyond question, and in both instances the occurrence furnished evidence of considerable importance regarding the possible habitat of the animals. The first specimen, consisting of two well-preserved columns of a large *Desmostylus* tooth, came into my hands through the kindness of Professor Andrew C. Lawson. It was obtained by Professor Lawson from Mr. W. L. Still, of La Panza, San Luis Obispo County, Calif. It was found in a cultivated field on Mr. Still's ranch. This locality

[1] *Am. Jour. Sci.*, 1888, p. 94.
[2] *Jour. of the Coll. of Science*, Imperial Univ. of Tokyo, Vol. 16, Art. 6, 1902.
[3] SCIENCE, N. S., Vol. XVI, p. 713.

is stated by Professor Lawson to be in a belt of Monterey shale which extends through this part of the country for many miles.

The second lot of material, including numerous tooth fragments was presented to the university by Mr. C. H. McCharles, of the University of California. It was obtained from a belt of shale six miles northeast of Santa Ana, Orange County, California, and was found in association with a large number of shark teeth.

In both instances the strata in which the *Desmostylus* remains occur are typical marine deposits, evidently of Miocene age. The fauna of these formations is in the main that of the open sea rather than of the shore, and it is difficult to conceive of proboscideans as occurring typically in these beds. The presumptive evidence, therefore, points pretty definitely toward an aquatic type as the one from which these remains have come.

Of the previously described American specimens we have known very little concerning the occurrence. The only one of which we have any definite information is in the collection of Professor Thomas Condon, of the University of Oregon, who informed me that it was 'picked up on the Yaquina beach, which is throughout marine.' Marsh states that the type specimen was found associated with the remains of a mastodon, a camel, a large edentate, and one or more species of horse, apparently indicating that the deposits were of alluvial or fresh-water origin. Unfortunately, there is no record to indicate exactly where or under what circumstances the material was obtained. The occurrence of the other three specimens from California is also very uncertain.

Influenced by the statement of Marsh, the writer inclined originally to the view that *Desmostylus* was obtained in fresh-water deposits. At the present moment, the only definite evidence fails to lend support to this view. In the case of the Japanese material the evidence is of much the same character as that now available here. It was associated with the teeth of the shark, *Carcharias japonicus*, and with the marine shell *Solen*. Impressions of some land plants were also found, and the authors expressed the view that the deposits, though marine, were of shallow-water origin. Possibly the range extends from marine beds through estuary deposits in both America and Japan.

Although the above notes do not give us very satisfactory information as to the habitat of *Desmostylus*, such evidence as is now

before us indicates that this form is an aquatic animal and, therefore, probably a sirenian rather than a proboscidean. If *Desmostylus* were a typical proboscidean distributed from Japan to southern California, one would expect to find it ranging some distance inland on both continents. While its non-appearance inland might be due to our having overlooked it in collecting, its appearance in the marginal marine deposits on both sides of the Pacific suggests that its wide range was over the sea.

NOTES ON THE GENUS DESMOSTYLUS OF MARSH

CONTENTS

INTRODUCTION

THE peculiar mammalian genus *Desmostylus* described by Marsh[1] as a sirenian is of considerable interest to palaeontologists, as it represents a peculiar combination of proboscidean and sirenian characters. It is, however, one of the most imperfectly known of the Pacific Coast vertebrate forms, the total amount of American material available for study including only a few teeth and some scattered fragments of skeletal elements. Recent discoveries seem to show that *Desmostylus* may be a valuable horizon determiner in geologic work in California, and may also have some importance in geological correlation between America and Asia. It has, therefore, seemed desirable to bring together all of the information available concerning this form, in the hope that such a statement may assist in the accumulation of further data relating to its structure and range.

OCCURRENCE

Particular attention has already been called[2] to the fact that all *Desmostylus* material of which definite information could be obtained has been found in marine beds. This statement is, however, not in accord with that of Marsh, according to whom the type material was found in association with remains of mastodon, camel, a large edentate, and one or more species of horse. Since the publication

[1] Marsh, O. C., Am. Jour. Sc., vol. 35, pp. 94 to 96, 1888.
[2] Merriam, J. C., Science, n. s., vol. 24, p. 151, 1906.

of his note on this subject it has been the writer's privilege to examine Marsh's type of *Desmostylus*, through the courtesy of Professor Richard S. Lull, of Yale University.   Contrary to the statement in Marsh's description, it was found that the original label describes the type of *Desmostylus* as coming from Contra Costa County, California, where it apparently occurred in association with marine Miocene invertebrates.   One of the specimens is embedded in rock similar to that of one phase of the marine Miocene of middle California.   The only objection to considering *Desmostylus* as a marine form has, therefore, disappeared.   It is to be presumed that the animal may have occupied the mouths of rivers and could, therefore, be found in estuary or even in river deposits.

Within the last few years a number of occurrences have come to light which indicate collectively that *Desmostylus* is limited to a comparatively narrow geologic zone of the Tertiary, and is presumably of value as a means of correlating widely separated deposits.

Numerous fragments of *Desmostylus* teeth have been found by Mr. F. M. Anderson to the north of Coalinga, in the western part of the San Joaquin Valley, in beds designated by him as the Temblor formation.   As nearly as can be determined, *Desmostylus* does not occur either above or below this zone in this region.   A record of an occurrence corresponding to that described by Mr. Anderson was obtained by the writer some years ago from a specimen in the museum of the California State Mining Bureau.   The location of this specimen is defined as Canoes Cañon, Sec. 33, T. 22 S, R. 16 E, Mt. Diablo Base and Meridian.   As shown by the mapping of this region by Ralph Arnold and Robert Anderson, a strip of the Vaqueros formation, corresponding approximately to the Temblor of F. M. Anderson, crosses the higher side of this section.   A tooth derived from this zone might be washed to any part of the section.

Farther to the south, on the west side of the San Joaquin Valley, F. M. Anderson reports *Desmostylus* at the Temblor horizon in the region of the Devil's Den.   On the east side of the valley in the Kern region Mr. Anderson finds it again in beds corresponding to his Temblor formation of the west side of the valley.

Important discoveries of *Desmostylus* remains were recently made in the Vaqueros formation north of Coalinga by Robert Anderson, and by Robert Anderson and R. W. Pack of the U. S. Geological Survey.   With the permission of the Director of the Survey,

through the courtesy of Mr. Anderson and Mr. Pack, the writer had the opportunity of examining this material. The most interesting specimens comprise a fine molar tooth and a portion of a tusk. The cheek-tooth (figs. 1*a* and 1*b*) corresponds almost exactly in form and size to the second upper cheek-tooth of a skull described by Yoshiwara and Iwasaki from Japan.

Other occurrences of *Desmostylus* in southern California include a number of fragments of teeth obtained by Mr. W. L. Still of La Panza, San Luis Obispo County, and brought to the writer's attention by Professor A. C. Lawson. These specimens are considered by Professor Lawson as occurring in association with shales and sandstones near the Vaqueros formation. Another collection of *Desmostylus* teeth was obtained by Mr. C. H. McCharles from a belt of shale and sandstone about six miles northeast of Santa Ana, Orange County (see fig. 3). These beds are considered by those who have examined them as probably near the horizon of the Vaqueros.

The occurrence of the type specimen being indicated only as in Contra Costa County, it is not possible to determine certainly the horizon at which it was found. There is, however, in the Tertiary of Contra Costa County a zone corresponding to that in which *Desmostylus* is known to occur in the region farther south, and the nature of the matrix suggests that this specimen came from one of the horizons of the Miocene.

The best preserved specimen of *Desmostylus* in the University of California collection (figs. 2*a* and 2*b*) is unfortunately labeled only with the name of the donor, who is no longer to be found.

Considering all of the California occurrences of *Desmostylus* remains concerning which we have any reliable data, there seems good reason to regard it as probably characteristic of the Vaqueros or Temblor horizon, and presumably not occurring much if any higher than the faunal zone of *Turritella ocoyana*, which marks the upper limit of the Temblor or Vaqueros as commonly recognized.

Outside of the region of California the only occurrence of *Desmostylus* known in America is that of a tooth obtained by Professor Thomas Condon from the beach of Yaquina Bay in the northern half of the Oregon coast. This specimen evidently came from middle Tertiary beds which are exposed along the beach, but it is not possible to make certain of the exact horizon from which it was

derived.   As nearly as can be determined the tooth came either from beds recognized as Oligocene, or from some part of the Miocene.   In as much as there are reasons for considering that the marine Oligocene of Oregon may correspond in age to the Temblor or Vaqueros of California, it is possible that the horizon of *Desmostylus* at Yaquina Bay is close to that of the definitely known occurrences in California.

Remains referable to *Desmostylus* are reported by Yoshiwara and Iwasaki[3] from the Tertiary of Japan.   They occurred in a tuffaceous sandstone lying some distance above a horizon containing many marine shells generally considered to be of Miocene age.   Associated with the *Desmostylus* bones were teeth of a shark (*Carcharias japonicus*), a marine shell (*Solen*), and impressions of some land plants.   The presence of plants suggests that the deposits were formed near shore, and presumably near the mouth of a river.   From such information as is available one might consider the Japanese *Desmostylus* as coming from Miocene beds.

Considering all of the evidence before us, it is clear that *Desmostylus* was a marine animal, which may have gone into the mouths of rivers; its known geographic distribution extended around the north Pacific from southern California to Japan; its geologic range in America is found in a zone near the base of the Miocene.   As the time equivalence of the formations in which *Desmostylus* occurs is not yet fully understood, later study may show that the downward limit of range corresponds to the Oligocene or that the upper limit corresponds to middle Miocene.

DENTITION

The teeth of *Desmostylus*, as known from the Californian specimens (figs. 1a to 2b), consist of several pairs of high pillars which are generally closely aggregated and nearly circular in cross-section. In some instances they are closely grouped and become angulated where they are in contact.   The pillars are generally arranged in pairs set transverse to the longest diameter of the crushing face. In some cases three pillars are present in the transverse row.   The average tooth comprises three pairs of pillars.   In one specimen four transverse rows are present.   In section (figs. 1b and 3) the pillars are seen to consist of an extraordinary thick enamel layer

[3] Yoshiwara, S., and Iwasaki, J., Jour. Coll. Sc. Imp. Univ. Tokyo, vol. 16, art. 6, 1902.

and a comparatively small dentine body. The enamel resembles in general characters that of the teeth in members of the mastodon group. In wear the pillars usually show a very thick rim of enamel surrounding a small central pit worn into the softer dentine. With wear the size of the central dentine area increases until, in a half-
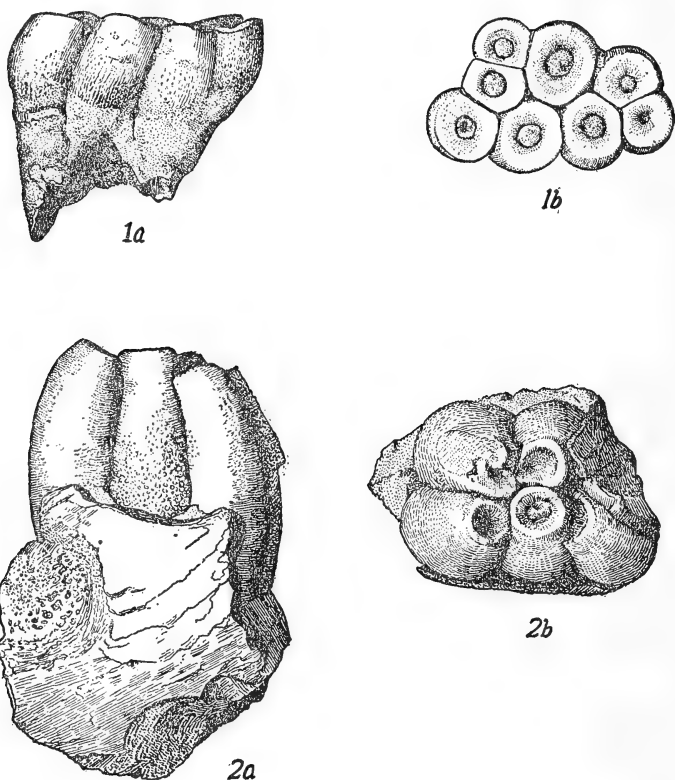
FIGS. 1a AND 1b. *Desmostylus*, sp.   M^1, $\times \frac{1}{2}$. Lower Miocene, north of Coalinga (NW $\frac{1}{4}$ sec. 29, T. 18 S, R. 15 E). Collected by Robert Anderson. Fig. 1a, lateral view; fig. 1b, occlusal view.

FIGS. 2a AND 2b. *Desmostylus*, sp.   M$_1$, no. 9091, $\times \frac{1}{2}$. California, exact locality unknown. Fig. 2a, lateral view; fig. 2b, occlusal view.

worn tooth, its diameter may about equal the thickness of the enamel ring. In the field the teeth are most commonly found broken up into fragments of pillars.

Of the known Japanese specimens very fortunately one includes a large part of a skull with a number of teeth in the jaws. In this individual there are three cheek-teeth shown in the upper jaws

(figs. 4 and 11) and three in the lower (figs. 5 to 7). The anterior tooth in each jaw is much smaller than the tooth immediately behind it, and was considered by Yoshiwara and Iwasaki as P^4 in the upper jaw and P_3 in the lower jaw. The anterior cheek-tooth, P^4, of the upper jaw consists of four pillars of which the posterior pair are relatively quite small. The second upper cheek-tooth, M^1, is at least three times as large as P^4. It consists of eight large pillars, of which three form the anterior transverse row, two pairs form the second and third transverse rows, and a single pillar forms the
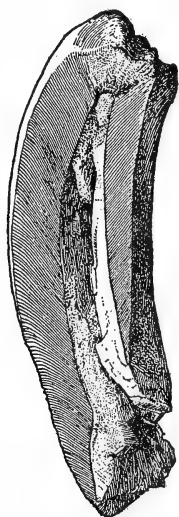
FIG. 3. *Desmostylus*, sp. Fragment of a cheek-tooth showing thickness of enamel. No. 10015, natural size. Lower Miocene?, near Santa Ana, California. Collected by C. H. McCharles.

posterior segment of the tooth. A third upper cheek-tooth, M^2, not yet in function, is seen in the jaw bone behind M^1.

In the lower jaw (figs. 5 to 7) there is less difference between the first and second cheek-teeth than in the upper series. The first two teeth, considered by Yoshiwara and Iwasaki as P_3 and P_4, each consist of several pillars, but P_3 is much the smaller tooth, and is short-elliptical instead of long-quadrate in cross-section. P_4 consists of three transverse rows of pillars with two each in the anterior and middle segments, and three in the posterior one. P_3 may be considered as having three transverse rows of two each with an isolated pillar at the anterior side of the tooth. The third lower

cheek-tooth, M_1, consists of only six pillars arranged in three transverse pairs, but it is much larger than the second tooth, or P_4.

As the Japanese specimen evidently represents a young individual, it is not entirely certain how many cheek-teeth were present normally in the jaw of the adult animal.
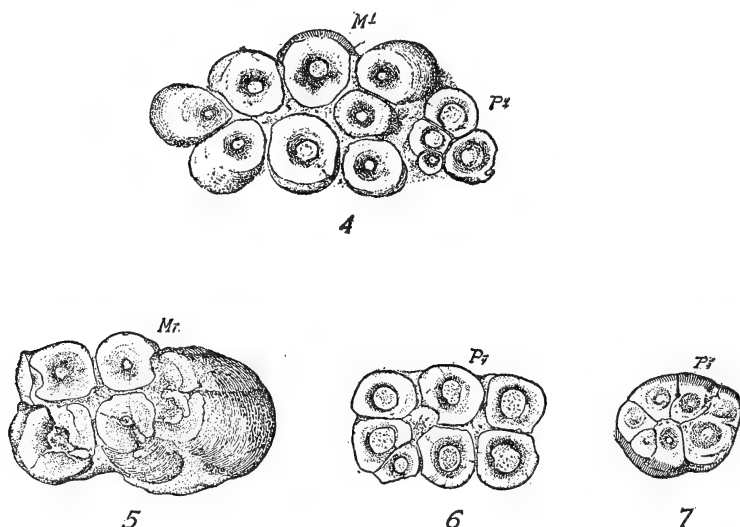
FIGS. 4 TO 7. *Desmostylus*, sp. Cheek-teeth in occlusal view, $\times \frac{1}{2}$. Miocene of Japan. Fig. 4, M^1 and P^4; fig. 5, M_1; fig. 6, P_4; fig. 7, P_3. (After Yoshiwara and Iwasaki.)
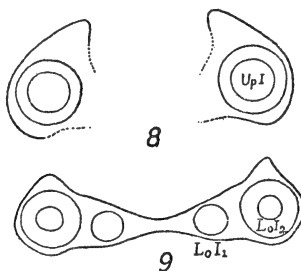
FIGS. 8 AND 9. *Desmostylus*, sp. Incisors in cross-section in the jaws, $\times \frac{1}{4}$. Miocene of Japan. Fig. 8, upper incisors; fig. 9, lower incisors. (After Yoshiwara and Iwasaki.)

In the specimen of *Desmostylus* described by Yoshiwara and Iwasaki there was a single pair of large tusk-like teeth in the upper aw and two pairs in the lower jaw (figs. 10 and 11). The tusks were considered as incisors. The upper pair seems, however, in doubtful relation to the maxillary, and may represent canines, as

also the posterior lower pair.   The tusks are said to reach a length of at least twenty centimeters.   They are circular in cross-section, and are entirely covered with a thick enamel (figs. 8 and 9).

As nearly as can be determined, the tusk fragment obtained by Robert Anderson and R. W. Pack from the Vaqueros formation of
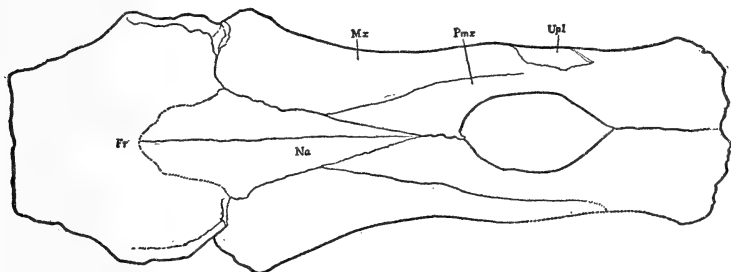
FIG. 10.   *Desmostylus*, sp.   Superior view of anterior region of the skull, $\times \frac{1}{6}$.   Miocene of Japan.   *Fr*, frontal region; *Na*, nasal; *Mx*, maxillary; *Pmx*, premaxillary; *Up I*, upper incisor.   (After Yoshiwara and Iwasaki.)
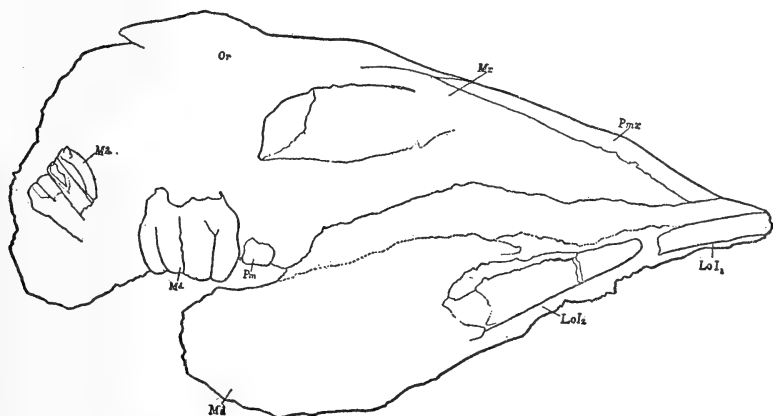
FIG. 11.   *Desmostylus*, sp.   Lateral view of a portion of the skull with the lower jaw, $\times \frac{1}{6}$. Miocene of Japan.   *Pmx*, premaxillary; *Mx*, maxillary; *Or*, orbital region; *Pm*, fourth upper premolar; M^1, first upper molar; M^2, second upper molar; *Md*, mandible; *Lo I_1*, first lower incisor; *Lo I_2*, second lower incisor.   (After Yoshiwara and Iwasaki.)

California corresponds in form and structure to the tusks of the Japanese specimen of *Desmostylus*.   It was about eighteen inches long, and was completely covered with enamel.   Only the tip was preserved in the collection examined by the writer.   This fragment is about one inch in diameter at a point less than two inches from the tip.   The enamel on this tooth is slightly roughened.

Skeleton

The skull of *Desmostylus* is known only through the specimen described from the Tertiary of Japan. The posterior region of the skull is broken away. The superior side from the frontals forward as represented in the illustration presented by Yoshiwara and Iwasaki (fig. 10) differs from all of the known sirenian forms. The premaxillaries completely surround the anterior narial opening, their posterior ends separating the acute anterior terminations of the nasal elements from the posterior border of the nares. The exact form of the nasals is not quite clear, but from the illustration they seem to extend backward between the anterior ends of the frontals. The maxillaries are large elements, forming a considerable part of the facial region.

In the large size of the nasals and maxillaries *Desmostylus* is more primitive than any other form referred to the Sirenia. The situation of the anterior narial openings seen here is different from that in other forms of this order. The other characters of the skull are unfortunately not clearly shown in this specimen.

Fragments of ribs and vertebrae referable to sirenians have been found in the middle Tertiary of California, and some or all of these remains presumably represent *Desmostylus*, but as yet it has not been possible to make certain of the relationships of these fragments.

Systematic Position

The evidence before us indicates that *Desmostylus* represents a group which is to be included in the Sirenia. The characters of the skull and dentition suggest that when the whole skeleton is seen this genus may be found to differ from the known groups sufficiently to make necessary its reference to a family distinct from those thus far described. The peculiar characters of the skull and dentition of *Desmostylus* add somewhat to the evidence which has been held to indicate relationship of the Sirenia to the Proboscidea.

MAMMALIA

FAUNA OF RANCHO LA BREA

RECENT DISCOVERIES OF QUATERNARY MAMMALS IN SOUTHERN CALIFORNIA

SEVERAL months ago Mr. F. M. Anderson called my attention to a deposit of bones occurring in asphalt beds near Rosemary Station about nine miles west of Los Angeles. In a small collection of specimens kindly presented to me by Mr. Anderson there were represented a number of Quaternary mammalian species which are either new to the fauna of the Californian region or have been very imperfectly known.

Recently Mrs. Ida Hancock, the owner of the property on which the asphalt deposits are located, has very kindly given to the University of California permission to carry on excavation work in these beds, and a considerable collection of valuable material has been obtained.

The beds in which the bones occur extend over many acres. So far as I am aware the bottom has not been reached in excavations carried to the depth of at least fifteen feet in quarrying the asphalt. Bones are scattered through a large part of the deposit, but are very unevenly distributed. In some localities they are present in large numbers and in fairly defined layers.

The asphalt has in many cases penetrated even the minute pores of the bone, but the original material of the skeleton is practically unchanged.

The remains recognized up to the present time include the following forms: *Elephas*, *Equus*, *Bison*, a mylodont, *Smilodon*, *Canis indianensis* (?), *Canis* (small species), and camel remains. Numerous bird bones and remains of insects are also found.

In a considerable number of cases large parts of skeletons are found together, showing that the carcasses were entombed so quickly that there was not sufficient time for decomposition to permit separation of the parts.

Of the specimens obtained up to the present time an extraordinarily large percentage represent carnivora. The number of

carnivores is certainly relatively larger than the usual percentage in a well-balanced fauna, and this abundance must be attributed to peculiar conditions under which the bones accumulated. Undoubtedly most of the remains are those of animals that have been entrapped or mired in the asphalt at times when it formed a deposit around tar springs. The surface of the asphalt is very sticky in some places at the present time, and where cuts are opened in it tar may ooze out. Such pools have probably existed here interruptedly through a long period, and particularly during Quaternary time when the deposit was forming. Carnivores are numerous because they were attracted by birds and mammals caught in the asphalt. Perhaps it is not entirely a coincidence that the carnivore remains are usually associated with those of birds or mammals, which would be their natural prey. The considerable number of young sabre-tooth cats present may indicate that the younger and less experienced individuals were more easily lured into the tar pools.

During the first examination of the beds several small, pebble-like bones were obtained which resembled the dermal ossicles of the ground-sloth, *Grypotherium*, recently described by Dr. A. Smith Woodward[1] from skin fragments obtained in a cave at Last Hope Inlet, Patagonia. The ossicles were in association with remains of a large ground-sloth somewhat similar to *Mylodon* in foot structure. Realizing that the peculiar conditions of accumulation offered an especially favorable opportunity for preservation of the dermal armor of a ground-sloth, during the second study of the deposits an attempt was made to find a specimen in which the armor might be recognized. Several hundred yards from the location of the first specimen, a large scapula resembling that of a mylodont was found partly exposed, with a row of small ossicles immediately over the outer side. The section of the bed containing these bones has recently been worked out, and the row of small bones proves to be the edge of a distinct layer including between 250 and 300 individuals. They mantle over the outer surface of the scapula, being removed from it by about an inch of asphalt.

The layer of bones as we find it has probably been disturbed somewhat and does not occupy its original position exactly, but the

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[1] A. Smith Woodward with Dr. F. P. Moreno, *Proc. Zool. Soc. Lond.*, 1899, pp. 144–156, pls. 13–15; also A. Smith Woodward, *Proc. Zool. Soc. Lond.*, 1900, pp. 64–79, pls. 5–9.

fact that it remains as a distinct layer with a tendency toward similar orientation of the individual ossicles indicates that the disturbance has not been great. As the position of the layer in the asphalt was nearly vertical, the presence of the large number of ossicles together may not be attributed to the washing together of scattered elements on the floor of a small basin of deposition.

The ossicles are not closely pressed together and are not superimposed. The individuals range in size from a cross-section of 6.5 x 4.5 mm. to 21 x 16 mm. Excepting a few of the largest ones, which are nearly square, the greater number are rounded and rather irregular in form. The outer side is in some cases more regularly modeled than the inner. The surface of the bones is somewhat roughened or pitted in some instances, but no markings are present which would be considered as definite sculpturing. The microscopic structure has not yet been examined.

In general the form, size and arrangement of the ossicles are much as in the bones in the *Grypotherium* skin from Patagonia. The skin fragment first described by Woodward was thought to represent mainly the region of the neck and shoulder. The Californian specimen mantles over the outer side of the scapula, and is presumably not far removed from its original position with relation to this bone. The generic position of the form represented by this specimen appears as yet somewhat uncertain, but a satisfactory determination of its affinities will probably be possible when the skeletal material available has been finally assembled.

THE SKULL AND DENTITION OF AN EXTINCT CAT CLOSELY ALLIED TO FELIS ATROX LEIDY

CONTENTS

INTRODUCTION

IN DECEMBER, 1908, Dr. William Bebb of Los Angeles obtained from the asphalt beds at Rancho La Brea, near Los Angeles, a feline skull of extraordinary size, and specifically unlike the cranial parts of any form thus far described from this continent. Dr. Bebb very generously permitted me to make a study of this remarkable specimen, for which my sincere thanks are due him. The skull has recently been presented by Dr. Bebb to the palaeontological museum of the University of California, and has been placed on exhibition.

The species represented by the skull obtained by Dr. Bebb seems to correspond in characters to the great cat described as *Felis atrox* by Leidy many years ago, from Quaternary beds in the state of Mississippi. This form was evidently one of the largest known species in the group of true cats, and seems to have ranged over at least the southern half of North America.

In comparing the Rancho La Brea specimen with Leidy's description and figure of the type of *Felis atrox*, the writer was very graciously assisted by Mr. Witmer Stone of the Academy of Natural Sciences of Philadelphia, who kindly made an examination of the type with reference to several doubtful points.

History of Type Specimen of Felis atrox

In 1853 Joseph Leidy described[1] and figured under the name of *Felis atrox* a portion of a lower jaw of a very large cat which seems to have been obtained in beds of Quaternary age, near Natchez, Mississippi. Regarding the occurrence of this specimen Leidy makes the following statement:

"The specimen belongs to this society (Amer. Philos. Soc.), and when first discovered was in company with several fragments of bones and a few teeth of other extinct mammalia, without labels, but from the condition of their preservation corresponding closely to that of some specimens, in several instances of the same animals, contained in the collection of the Academy of Natural Sciences, from ravines in the neighborhood of Natchez, Mississippi, I have no doubt they were derived from the same locality, and probably constitute the donation entered upon the minutes of the Society, April 1st, 1836, of some fossil remains from the vicinity of Natchez, presented by William Henry Huntington, Esq."

The specimens accompanying the large cat jaw in the collection of Mr. Huntington included remains of *Mastodon*, *Bison*, and *Equus americanus*. Other remains found at Natchez included *Mastodon*, *Megalonyx*, *Mylodon*, *Bison*, *Cervus*, *Equus*, and *Ursus*.

The type specimen consisted of the anterior half of the left ramus of a lower jaw including all of the teeth excepting the incisors. This specimen was designated as the American lion by Leidy, and was shown to represent a species larger than the Recent lion and tiger, and larger than the extinct cave lion of Europe.

Since the description of the type specimen of *Felis atrox* no other material has been published upon which has been referred to this species. The only described specimen known to the writer which might possibly be referred to this form is the fragmentary type of *Felis imperialis*, which Leidy obtained from deposits presumed to be of Quaternary age occurring in Livermore Valley, California.

Occurrence and Age of Rancho La Brea Specimen

The skull which forms the subject of this paper was obtained by Dr. William Bebb in the asphalt beds at Rancho La Brea, about

[1] Leidy, Joseph, Amer. Philos. Soc. Trans., New Ser., vol. 10, p. 319.

nine miles west of Los Angeles.   It was associated in these deposits with numerous other mammalian remains including the following forms: *Canis indianensis; Canis*, n. sp.; *Smilodon* (?) *californicus; Bison antiquus; Elephas*, sp.; *Mastodon*, sp.; *Camelops*, sp.; *Paramylodon nebrascensis*.   The fauna as a whole cannot be considered as other than Quaternary, although the particular division of that system represented is not as yet clearly determined.

<center>Skull</center>

The general form of the skull (pl. 26) in the Rancho La Brea specimen is remarkably similar to that in the Recent African lion and to the cave lion of the European Quaternary.   The principal peculiarity noticeable in the broader outlines of the skull is seen in the width of the muzzle compared with the basal length.   The breadth of the skull across the zygomatic arches, and also across the upper jaws measured through the superior sectorials is compared with the basal length about 5 per cent. less than in the specimen of the African lion in the University collections; while the transverse diameter of the muzzle measured over the narrowest point opposite the diastema is about 5 per cent. greater than in the African lion.

The widening of the muzzle is probably not due to vertical compression; on the contrary the position of the nasal bones indicates a slight lateral flattening.

In its superior outlines the skull approaches the lion more closely than the tiger.   The planes of the frontal and nasal regions seem to have been nearly identical, and the angle which the nasal region makes with the superior line of the sagittal crest is smaller than in the tiger or in the puma.   A considerable portion of the frontal region has been crushed and corroded, but as nearly as can be determined, it was originally nearly flat, rather than convex as in the tiger.

The sagittal crest shows about the same degree of development as in the African lion, and the superior line of the crest is nearly straight as in that form.

The brain case is somewhat smaller than in either the lion or the tiger.

In the *facial region*, the anterior narial opening as nearly as can be determined is not materially different from that of the African

lion. The form and relations of the nasal elements posteriorly can unfortunately not be seen, owing to corrosion of the skull at this point. The frontal process of the left maxillary, which is well preserved, is rather broadly truncated posteriorly, which probably indicates that the terminations of the nasals, frontals and maxillaries in this region had much the same arrangement as in the tiger.

The *occiput* shows a rather marked narrowing immediately above the mastoid region, due in a large measure to the reduction of the lambdoidal ridges on each side just above the level of the upper side of the foramen magnum. The middle region of the occiput is marked by a sharper ridge than the corresponding median elevation of this region in the lion. In the tiger this region is generally more evenly rounded than in the lion.

The region of the *basioccipital* (fig. 1) is flatter in the space between the auditory bullae than in the lion, and on both sides the greatly roughened area for the attachment of the longus capitis is situated nearer the posterior lacerated foramen than in the lion or tiger. The median tubercle for attachment of the constrictor pharyngis superior, which sometimes appears on the inferior side of the basioccipital and basisphenoid in the lion, is absent in this specimen, as it is in *F. spelaea* according to Dawkins and Sanford.

The *auditory bullae* are much smaller than in either the lion or the tiger, and are smaller than the bullae of any modern feline known to the writer. The entotympanic portion is much less inflated than in the lion. The ectotympanic region is much flattened, and is quite distinctly set off from the entotympanic portion. The anterior spine of the ectotympanic region extends farther forward than the anterior extension of the entotympanic portion, and reaches forward over the base of the zygomatic arch to a point a very short distance behind the middle of the glenoid fossa. The space between the mastoid and postglenoid processes, and opposite the external auditory meatus, is somewhat wider than in the lion.

The external auditory meatus is situated relatively far out from the median line of the skull; the portion of the opening nearest the median line being laterad of the inner side of the stylomastoid

foramen, as well as considerably farther out from the median line than the inner end of the postglenoid process.

The paroccipital process is relatively prominent, owing largely to the reduction in size of the auditory bulla.

The *lower jaw* in this species (fig. 2) is slightly heavier than that of the Recent lion and tiger specimens available to the writer, but is apparently not more massive than in some specimens of the European spelaean form. The symphyseal region is somewhat broader and more massive inferiorly than in the lion. This region is, however, covered in part with a rough growth of bone which is more pronounced on the right ramus, and may be due partly to age and partly to unusual conditions existing only in this individual. In one of the specimens of *F. spelaea* figured by Dawkins and Sanford[2] the symphysis is nearly as heavy as in the specimen from Rancho La Brea.

The inferior margin of the jaw is concave as in the tiger, owing to the prominence of the symphyseal region and of the angle. The most prominent portion of the middle region of the inferior border corresponding to the "ramal process" of Dawkins and Sanford is below the anterior lobe of M_1. The masseteric fossa is very deep, and its extreme anterior border reaches forward to a point opposite the middle of the inferior carnassial. The inferior border of the anterior portion of the masseteric fossa is marked by a sharp upward twist occurring just below the deepest portion of the fossa as in one of the specimens of *F. spelaea* figured by Dawkins and Sanford.[3]

The coronoid process is extraordinarily large and high. The superior portion swings backward somewhat as in the tiger, so that the posterior extremity extends behind the condyle.

The form of the angle is intermediate between that of the lion and the tiger; as it projects inferiorly more than in the lion, and less than in the tiger posteriorly.

Some of the *foramina* show features which seem to be characteristic.

The infraorbital foramina are rather narrowly oval as in the tiger, and are relatively smaller than in the lion.

[2] British Pleistocene Mammalia, pl. 1, fig. 1.
[3] British Pleistocene Mammalia, pl. 1, fig. 1.

In the palatine region there is a slight but noticeable peculiarity in the situation of the posterior palatine foramina. The posterior borders of these foramina in this specimen reach back to a point behind the superior molars. In the lion and tiger they are situated somewhat farther forward.

In the lateral region of the skull the foramen rotundum is separated from the sphenoidal fissure by a much thinner bony septum than in the lion, and the space separating this foramen from the foramen ovale seems comparatively wide.

In the basicranial region (fig. 1) the stylomastoid foramen is not situated farther out from the median plane of the skull than is the median or innermost portion of the inferior border of the auditory meatus. In the lion and tiger the stylomastoid foramen is situated relatively much farther from the median plane.

The condylar foramen is in this specimen set relatively far back so that on the left side of the skull it can scarcely be said to be included in the opening of the posterior lacerated foramen.

MEASUREMENTS OF SKULL

Length from anterior side of premaxillary to posterior side of occipital
    condyles.. 395. mm.
Greatest length from anterior side of premaxillary to inion........... 438.5
Greatest width of zygomatic arches............................... 281.
Least width across muzzle behind superior canines.................. 136.
Width between outer sides of alveolar margins of superior car-
    nassials.. 139.
Length from a line drawn between the postorbital processes of the
    frontals to the extreme occipital protuberance.................... 197.
Distance from upper end of foramen magnum to the posterior end of
    sagittal crest.. 88.
Length of left ramus of mandible from extreme anterior end to posterior
    side of condyle.. 291.5
Length of mandible from anterior side of canine at alveolar border to
    posterior side of condyle...................................... 289.5
Height of lower jaw below protoconid of P_4......................... 55.
Height of lower jaw below protoconid of P_4 in *F. atrox*, type specimen. 55.
Thickness of lower jaw below protoconid of P_4..................... 30.8

DENTITION

Superior Dentition.—The upper teeth are unfortunately considerably worn and broken, so that only P^3 remains absolutely intact. I^3, P^2, and M^1 had disappeared before the specimen was discovered.

The superior canines are unfortunately represented only by the

broken basal portions. They are relatively large compared with the anteroposterior diameter of the cheek teeth and compared with the length of the skull. A number of detached superior canines in the collection are considerably smaller than that of no. 14001, but may represent another species.

The form of P^3 resembles that of the modern African lion excepting in the somewhat greater elongation of the cusps in the lion, and in the slightly larger size of the posterior basal tubercle in the Rancho La Brea specimen. The crown of this tooth is generally somewhat lower than in the lion, and in *F. spelaea*, and in this respect resembles the tiger.

Both superior carnassials are considerably broken on this specimen, but the form is well shown (fig. 3) on a loose tooth (no. 12501) obtained in the same deposit. This tooth is about comparable to that of the Recent tiger, excepting that the antero-external prominence in front of the protostyle is not as well developed as in the tiger, and the crown is not quite as low.

M^1 seems to have been distinctly two-rooted on one side of the skull, and the roots were nearly separated on the other side.

Inferior Dentition.—The elements of the inferior cheek tooth dentition of the specimen have fortunately been preserved intact. The inferior canines and all of the incisors but the left I_3 have disappeared.

The space occupied by the inferior incisors is relatively small, being only a little greater than in a Recent African lion skull of much smaller size. The roots of the incisors remaining stand in a line which is bowed backward rather sharply compared with the slightly curved transverse line of the incisors in the lion and tiger.

The inferior canines have a greater anteroposterior diameter compared with that of the inferior carnassial than in the lion, but are smaller in comparison with the upper canines.

The diastema is relatively a little shorter than in the Recent lion and tiger, but is not as short as in one of the specimens of *F. spelaea* figured by Dawkins and Sanford.[4]

In P_3 the postero-internal portion of the cingulum is more strongly swollen laterally than in the lion and tiger. P_4 resembles quite closely the form of this tooth in the African lion, excepting

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[4] British Pleistocene Mammalia, pl. 1.

that the anterior and posterior cusps are perhaps a little more compressed laterally and are less acute. The protoconid is approximately triangular in cross-section, the inner angle of the triangle extending down to the cingulum as a rather prominent ridge.

M_1 corresponds in relative size and proportions quite closely to the inferior carnassial of the African lion. It possesses however a well-developed heel and a minute cusp corresponding to the metaconid. Although the paraconid blade is somewhat worn it seems to show evidence that its anterior margin sloped backward more strongly than the nearly vertical anterior border of this portion of the tooth as it may appear in the African lion.

MEASUREMENTS OF DENTITION

	No. 14001, Rancho La Brea specimen	F. atrox, type specimen	F. leo
Length, anterior side of superior canine at alveolar margin to posterior side of P⁴	134.5 mm.		98.
Length, anterior side P² to posterior side P⁴	91.5		67.5
Width, from median side I¹ to lateral side I³	28.		24.
Superior canine, anteroposterior diameter at alveolar margin	42.3		22.5
Superior canine, transverse diameter at alveolar margin	28.7		16.3
P², anteroposterior diameter of alveolus	10.		9.6
P³, greatest anteroposterior diameter	29.		23.
P³, greatest transverse diameter	14.6		11.6
P⁴, greatest anteroposterior diameter	43.		32.
P⁴, greatest transverse diameter across deuterocone	21.5		16.3
P⁴, greatest anteroposterior diameter of protostyle	10.		7.
Width between medial borders of alveoli of inferior canines	29.5		25.6
Inferior canine, anteroposterior diameter of alveolus	39.3	33.	23.2
Inferior canine, transverse diameter of alveolus	23.5	20.8	15.2
Length, anterior side of canine at alveolar border to posterior side of M₁	156.8	162.	115.
Length of inferior cheek tooth series	86.7	86.5	64.6
P₃, greatest anteroposterior diameter	20.5	21.3	18.2
P₃, greatest transverse diameter	11.5		10.
P₄, greatest anteroposterior diameter	32.2	31.	23.8
P₄, greatest transverse diameter	16.5		13.5
M₁, greatest anteroposterior diameter	34.	32.	24.5
M₁, greatest transverse diameter	16.8		12.5
M₁, greatest anteroposterior diameter of paraconid blade	16.		11.8

Diagnostic Characters

Felis atrox Leidy, variety *bebbi*

Felis atrox, Leidy, Am. Philos. Soc. Trans., New Ser., vol. 10, p. 319.

Type specimen of Mississippi form Coll. Acad. Nat. Sc. Philad. Obtained in beds of presumable Quaternary age near Natchez, Mississippi. *Bebbi* form based on specimen 14001, Univ. Calif. Col. Vert. Palae., from the Quaternary of Rancho La Brea, California.

Muzzle very wide compared with the length of the skull. Postorbital processes of the frontal relatively far back. Brain case small. Auditory bullae small. Anterior spine of ectotympanic region extending much farther forward than entotympanic portion. Occiput high and narrow.

Coronoid process very high and wide, and set near median end of condyle. Masseteric fossa very deep and showing a marked excavation as far forward as the middle of the inferior carnassial. Symphyseal region wide inferiorly (possibly an age or individual character). Anterior outline of symphyseal region more nearly normal to the inferior line of the mandible than in the lion or tiger. Condyles set low with reference to alveolar margin. Angle produced inferiorly somewhat farther than in the lion and tiger.

Infraorbital foramen smaller than in the lion or tiger, and situated a little farther back with reference to the P^4. Condylar foramen tending to be separated from posterior lacerated foramen on one side of the skull.

Canines relatively large, and the incisors small or set in a relatively narrow space. M^1 two-rooted. Inferior carnassial with metaconid, and with a well-marked heel developed on the cingulum. Protoconid of P_3 and of P_4 nearly triangular in horizontal cross-section. Inner ridge of the protoconid of P_4 relatively prominent at the base.

Individuals of this species of large size.

Affinities

Relation to Felis atrox Leidy.—The lower jaw of the Rancho La Brea specimen approaches very closely in measurements the peculiar feline jaw from Natchez, Mississippi, which served as Leidy's type of *Felis atrox*. Leidy's original specimen unfortunately consisted of only a half of a lower jaw with the cheek teeth and the

canine. The comparable dimensions are surprisingly close, particularly in the case of the cheek teeth, as is shown in the table of measurements (p. 721). The cheek teeth are similar in the lack of elevation of the cusps, and in the form of the cusps of P_4. The principal differences are found in the slightly longer anteroposterior diameter of the canine, in the greater development of the anterior basal tubercle of P_3, the shorter diastema, and possibly the greater development of the antero-inferior portion of the symphyseal region of the Rancho La Brea specimen. Slight differences may also exist in the reduction of the posterior basal tubercles of M_1 in the type specimen. This character is, however, always more or less variable.

Mr. Witmer Stone, who has kindly examined Leidy's type for me, finds a slight indication of an interior basal tubercle on P_3 of the type, though it is not shown in Leidy's figure. This character is more or less variable in the lion.

The form of the mandible is not certainly to be depended upon for specific diagnosis, as the type specimen was covered with a thick ferruginous coating, which may be supposed to have disguised its form somewhat. The marked prominence represented on the inferior border of the jaw below the anterior end of P_4 in Leidy's figure, and considered by Dawkins and Sanford[5] as a possible ramal process, is probably to be considered as principally an irregularity of the ferruginous coating of the jaw. Mr. Witmer Stone, who examined the type with reference to this feature, states that "it has been much exaggerated in the figure, or has been removed since." Mr. Stone believes that it was without question part of the matrix.

The form of the symphyseal region in the Rancho La Brea specimen is somewhat different from that in the type, in which the antero-inferior region is gently rounded, rather than markedly angular. Variation of this nature may be due in part to difference in age. A considerable irregularity in the roughened surface of the bone in the antero-inferior portion of the symphysis in the Rancho La Brea specimen is possibly in part an individual peculiarity.

While there seems little doubt that the Rancho La Brea specimen

[5] British Pleistocene Mammalia, part 3, p. 161.

is specifically identical with *Felis atrox* Leidy, the slight differences in size of canine, form of P_3, length of diastema, and form of the symphyseal region of the jaw make it desirable to refer to this type as the *bebbi* form, in contrast to the typical specimen.

Relation to Felis imperialis Leidy.—The type of Leidy's *Felis imperialis*[6] was obtained by Dr. Lorenzo G. Yates in a gravel deposit at Livermore Valley, California. In the same beds there were also obtained remains of *Bison latifrons, Auchenia hesterna, Elephas, Equus,* and *Canis indianensis.* This collection taken as a whole indicates the Quaternary age of the deposit. There is, however, no definite statement as to how closely the specimens represented in the collection were associated.

The type specimen consisted of an upper jaw fragment containing P^3, and showing the alveoli of P^2 and the canine. It is considerably smaller than the Rancho La Brea specimen, as is indicated by the following table of comparative measurements:

	F. imperialis, type	Rancho La Brea specimen
Length, from posterior side of canine alveolus to posterior side of P^3	45.4	54.
P^3, anteroposterior diameter	23.7	29.
P^3, height measured from cingulum to apex of protocone	14.8	15.5
Diameter of canine alveolus	29.2	42.3

A perfectly preserved upper canine in the University collections from Rancho La Brea agrees almost exactly in size with that of the type of *F. imperialis.*

The fragmentary nature of the type of *F. imperialis* makes it nearly impossible to determine certainly whether it is to be considered identical with *F. atrox.* The difference in size amounting to about one-fifth is probably not sufficient to exclude it from *F. atrox.* The only other character available for comparison is found in the form of P^3. This tooth is according to Leidy's figure[7] relatively high, measured from the cingulum to the apex of the protocone. In the corresponding tooth of the Rancho La Brea specimen of *F. atrox* the height is relatively less, or the tooth rela-

[6] Leidy, J., Proc. Acad. Nat. Sc. Philad., 1873, p. 259.

[7] Leidy, J., U. S. Geol. Surv. Terrs., vol. 1, 1873, pl. 31, fig. 3.

tively longer anteroposteriorly. In the *F. imperialis* specimen the posterior cusp is higher with relation to the posterior basal tubercle. The high form of P³ is rather characteristic of the recent puma, while the lower form is seen in the tiger. P³ of the lion is somewhat higher than in the tiger. Some doubt must exist as to whether this character is definite enough to warrant the separation of the *F. imperialis* specimen as a distinct species, even if the tooth in question is represented with absolute accuracy in Leidy's figure.

Leidy suggested that *F. imperialis* might be found to represent a young individual of the *F. atrox* type, and the range of size in the specimens available from Rancho La Brea might be considered as evidence pointing in this direction.

A milk carnassial of a large cat of the *Felis* type described by Bovard[8] from the Quaternary of Potter Creek Cave, was recognized as possibly representing *Felis imperialis*. This specimen, as shown by the table of measurements below, corresponds to the Recent African lion in dimensions. It represents an animal nearer to the size of the type of *F. imperialis* than to that of the Rancho La Brea specimen.

MEASUREMENTS OF SUPERIOR MILK CARNASSIALS

	No. 3825, Potter Creek Cave	Recent African Lion	Puma
Anteroposterior diameter	24.6 mm.	24.3	16.
Transverse diameter	8.2	8.	4.6

Issued August 24th, 1909

[8] Bovard, J. F., Univ. Calif. Publ. Geol., vol. 5, p. 163.
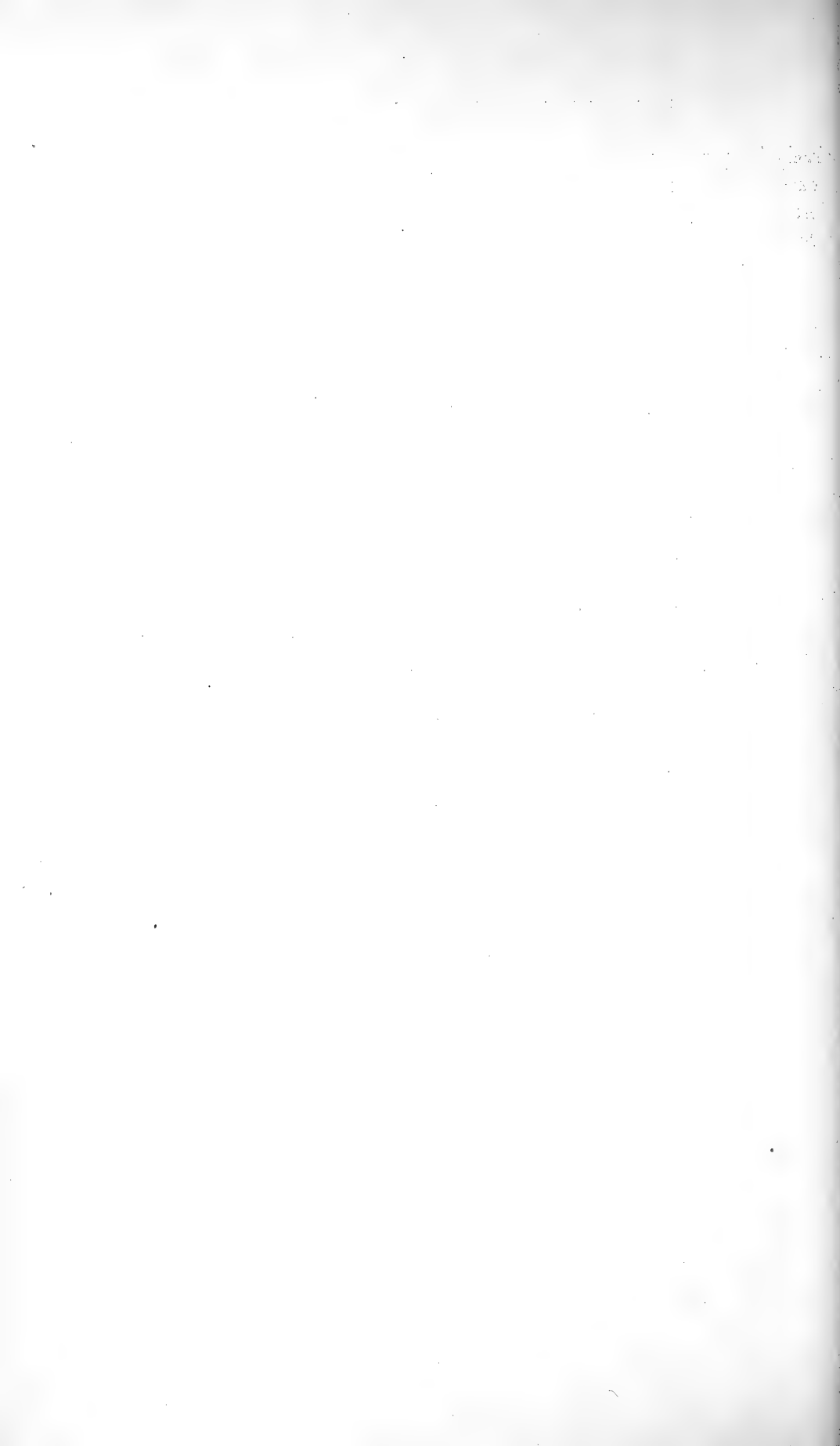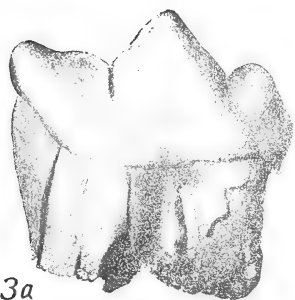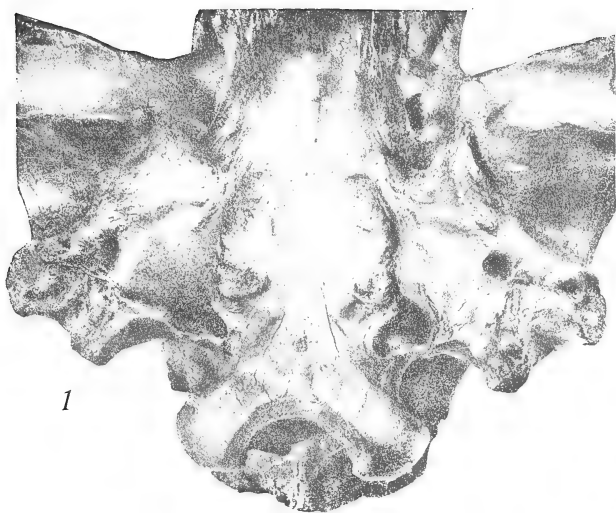
FIG. 1.   *Felis atrox*, variety *bebbi*.   Basicranial region, no. 14001, × .45.   From the Quaternary of Rancho La Brea.

FIG. 2.   *Felis atrox*, variety *bebbi*.   Mandible, no. 14001, × ⅖.   From the Quaternary of Rancho La Brea.   The angular process is incomplete on this ramus.

FIG. 3.   *Felis atrox*, variety *bebbi*.   Right superior carnassial; *a*, inner side; *b*, occlusal view.   No. 12501, natural size.   From the Quaternary of Rancho La Brea.

Felis atrox, variety *bebbi*

Skull, no. 14001, a little more than one-third natural size ($\times$ .367). From the Quaternary of Rancho La Brea.

NEW MAMMALIA FROM RANCHO LA BREA

CONTENTS

I
N THE collections of mammalian remains from Rancho La Brea
there are a number of mammalian species which have not as
yet been described. As it is necessary to list a number of
these forms in several publications, it is desirable to present the
following brief descriptions of the species:

CANIS ORCUTTI, n. sp.

Type specimen no. 10842, Univ. Calif. Col. Vert. Palae., from the
asphalt beds of Rancho La Brea near Los Angeles, California.

This species is represented by a considerable number of speci-
mens, amounting to something less than ten per cent. of the total
number of skulls representing the Canidae in the Rancho La Brea
fauna. The species is closely related to *Canis ochropus* Esch-
scholtz now living in Southern California. The skulls of *Canis
orcutti*, though showing approximately the same length as the liv-
ing *C. ochropus*, are noticeably broader across the palate and zygo-
matic arches. The mandible is considerably higher, particularly
below the molars, and is also thicker transversely than in the liv-
ing form of this region. The dimensions of the teeth do not vary
greatly from the living species except in the thickness of both the
upper and lower carnassials, which are much heavier in the fossil
form. M^1 tends also to be somewhat heavier and broader on the
median side than in the typical *C. ochropus*, and in this respect
more nearly approaches the typical *C. latrans*. In M_1 the meta-
conid seems to be slightly less prominent medially than in the typ-

ical *C. ochropus*, possibly owing to the greater thickness of the trigonid blade in the fossil form.

A skeleton of this species which has been assembled from parts of separate individuals seems to show quite distinctly that the animal was a rather slender, long-legged creature and evidently swift footed as the living coyotes.

MEASUREMENTS

No. 10842

Length from anterior side of premaxillaries to posterior side of occipital condyles	188.5 mm.
Width across zygomatic arches	108
Width between outer sides of tritocones of P^4	65
Least width between superior borders of orbits	38
Width between postorbital process of frontals	55
Length, posterior side of superior canine to posterior side of M^2	80.5
Length, anterior side of P^4 to posterior side of M^2	37.3
P^3, anteroposterior diameter	13.3
P^4, anteroposterior diameter	21.2
P^4, thickness across protocone	8.5
M^1, anteroposterior diameter measured along outer border	13.3
M^1, greatest transverse diameter	16
M^2, anteroposterior diameter measured along outer border	7.3
M^2, greatest transverse diameter	10.5

No. 11278

Length, anterior end of left ramus of mandible to middle of posterior side of condyles	145.5 mm.
Height of mandible below posterior side of P_2	17
Height of mandible below posterior side of M_1	22.5
Thickness of mandible below protoconid of M_1	11.8
Length, posterior side inferior canine to posterior side M_2	85
P_3, anteroposterior diameter	11.7
P_3, greatest transverse diameter	4.8
M_1, anteroposterior diameter	22.9
M_1, greatest transverse diameter of trigonid portion	9.5
M_2, anteroposterior diameter	9.8

Canis andersoni, n. sp.

Type specimen no. 12249, Univ. Calif. Col. Vert. Palae., from the asphalt beds of Rancho La Brea near Los Angeles, California.

This species is represented by a young adult skull of a small wolf with a much smaller and also relatively broader skull than *C. orcutti*. Though this specimen represents a young individual it differs so much in form from all the other known species in this region that it seems necessary to refer it to a distinct specific group.

MEASUREMENTS

No. 12249

Length from anterior side of premaxillaries to posterior side of occipital condyles..	166.1 mm.
Width across zygomatic arches....................................	91
Width between outer sides of tritocones of P^4......................	56
Least width between superior borders of orbits....................	31.9
Width between postorbital process of frontals.....................	38.2
Length, posterior side of superior canine to posterior side of M^2.......a,	64.5
Length, anterior side of P^4 to posterior side of M^2..................a,	36.5
P^4, anteroposterior diameter.....................................	20
P^4, thickness across protocone...........................'..............	7.8

a, approximate.

CANIS OCCIDENTALIS FURLONGI, n. var.

Type specimen no. 11283, Univ. Calif. Col. Vert. Palae., from the asphalt beds of Rancho La Brea near Los Angeles, California.

There are in the Rancho La Brea collections several fragmentary specimens representing a wolf considerably smaller than the smallest individuals of *Canis indianensis* type, and evidently representing a form closely related to the existing North American timber wolves. In the details of structure the teeth are, however, distinguishable from those of the living forms.

In the type specimen, which is a right maxillary with the molars and carnassial, the anterior region of the palate seems relatively narrow, though perhaps not narrower than in the existing species.

The superior carnassial is massive and the deuterocone seems to have been small. On M^1 the hypocone is much larger than in *C. indianensis* and has approximately the same size as in *C. pambasileus*. The anterior end of the hypocone cusp is extended around the anterior side of the protocone as a faint ridge, instead of being interrupted on the antero-internal portion of the tooth as in *C. indianensis*. M^2 is rather narrow anteroposteriorly; the metacone is small and the hypocone seems also to be relatively small.

In a fragment of a lower jaw accompanying specimen 11283 the carnassial possesses an exceedingly weak metaconid, while the entoconid is slightly larger than in the average specimen of *C. indianensis*. The metaconid is even weaker than in *C. indianensis* and approaches the relative size seen in a specimen of *C. pambasileus* available. On M_2 the protoconid seems slightly smaller and the heel portion relatively larger than in *C. indianensis*, though the metaconid is relatively small compared with the hypoconid. The

proportions of the talonid region with reference to the trigonid portion of the tooth are much as in the Recent wolves.

In another specimen (no. 10733), of nearly the same dimensions, from this locality the hypocone of M^1 is smaller than in specimen 11283, though larger than in the typical *C. indianensis*. The anterior extension of the hypocone ridge around the anterior side of the protocone is also interrupted as in *C. indianensis*. M^2 is in this specimen of the narrow form with small metacone and hypocone as in no. 11283. P^3 differs from the corresponding tooth of *C. indianensis* in being very narrow instead of wide posteriorly, and in the almost entire absence of a posterior basal tubercle behind the posterior cusp. The portion of the palatine region represented suggests narrowing anteriorly. This specimen almost bridges the gap between the *C. occidentalis* and the *C. indianensis* types but is nearest to *C. occidentalis furlongi*.

MEASUREMENTS

	No. 11283	No. 10733
Length, posterior side of superior canine to posterior side M^2....	81.5 mm.	
Length, anterior side P^4 to posterior side M^2..............	44.7	
P^4, anteroposterior diameter.............................	23.6	24 mm.
M^1, anteroposterior diameter along outer border............	16	15.5
M^1, greatest transverse diameter........................	19.3	18
M^2, anteroposterior diameter along outer border............	8	8.2
M^2, greatest transverse diameter........................	10.8	10.5
Width, from outer side of alveolus of M^1 to median line......	39	37.7
Width, from outer side of alveolus of P^1 to median line.......	18	
M_1, anteroposterior diameter.............................	27	
M_1, thickness measured across protoconid.................	11.5	
M_2, anteroposterior diameter............................	11	

LYNX CALIFORNICUS FISCHERI, n. var.

Type specimen no. 11287, Univ. Calif. Col. Vert. Palae., from the asphalt beds of Rancho La Brea near Los Angeles, California.

Two small cats of the *Felis* type are represented in the asphalt fauna by lower jaws. One specimen closely resembles in all of its characters *Lynx californicus* found at the present time in Southern California. In another form which is made the type of the new variety, *fischeri*, the jaw has about the same length as in the living species but is much more slender and the carnassial is somewhat larger. As yet no complete skeleton material of this form has been obtained.

<div align="center">MEASUREMENTS</div>

|	No. 11287
Length, posterior side of canine alveolus to posterior side of M_1	33.9 mm.
M_1, anteroposterior diameter	11.2
Height of mandible below protoconid of M_1	12.2
Thickness of mandible below protoconid of M_1	7.5

Issued January 31, 1910

NOTE ON A GIGANTIC BEAR FROM THE PLEISTOCENE OF RANCHO LA BREA

WITH the exception of a single tooth obtained by the writer during his first examination of the Los Angeles asphalt beds in 1906, no remains representing the bear family are known to have been obtained from Rancho La Brea until very recently. A few months ago Mr. Guintyllo, Assistant in Palaeontology at the University of California, called the attention of the writer to a small collection of foot-bones representing a gigantic bear, obtained by Mr. Eugene Fisher during the excavation work carried on for the University of California at Rancho La Brea. As the bones which have recently come to light seem to represent an animal of the same type as that suggested by the tooth found some years ago, it seems desirable to place on record the information available.

The tooth (figs. 1 and 2) obtained in 1906 is a very large lower canine, differing decidedly from the canine teeth of the carnivore species thus far described from Rancho La Brea. It is of extraordinarily large size, exceeding in dimensions the inferior canines of *Felis atrox bebbi* (the enormous lion of Rancho La Brea), *Arctotherium simum* (the cave bear of Northern California), and the gigantic Recent Alaskan bears. The crown of the tooth is short and thick, and the curve of the posterior border is more sharply marked than in most forms. It is thicker transversely and more strongly concave posteriorly than in *Felis atrox bebbi*. In general the crown resembles that of the bears more closely than any of the other groups. The sharpness of the bend in the middle of the posterior border suggests *Arctotherium simum*, but the tooth seems slightly larger and less slender than in that form. In the relative shortness and thickness of the crown it resembles some of the large Alaskan species of *Ursus*, but is larger and less concave posteriorly than in the species at hand for comparison. The tooth may be referred ten-

tatively to *Arctotherium*, as it approaches this genus more closely than to other forms.
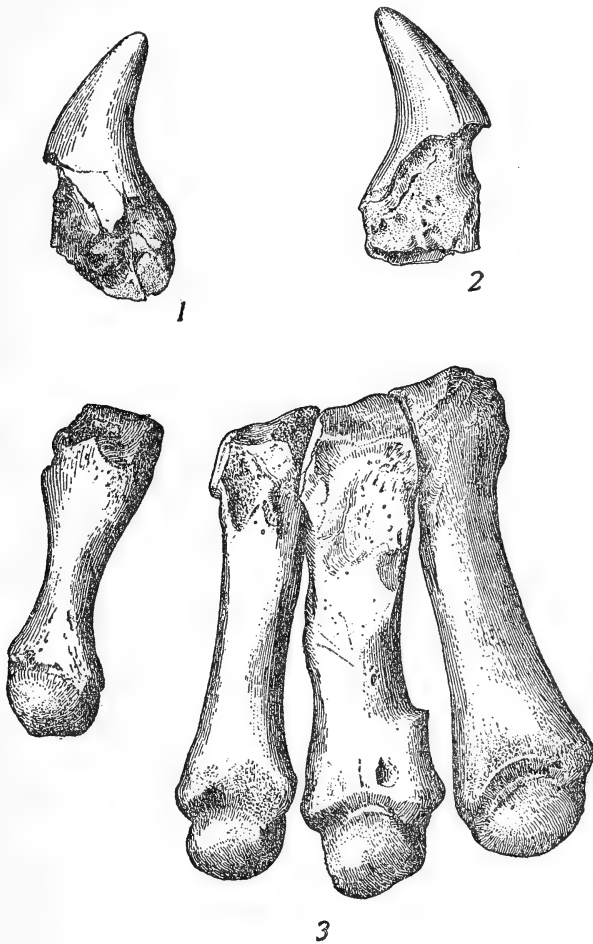
FIGS. 1 AND 2. *Arctotherium californicum.* Inferior canine tooth, no. 10600. × ½. Fig. 1, outer side; fig. 2, inner side.

FIG. 3. *Arctotherium californicum.* Metacarpal elements. Type specimen, no. 17754. × ½.

The foot-bones available for study consist of metacarpals 1, 3, 4 and 5, and the pisiform. They exceed considerably in size the very largest known specimens of *Arctotherium simum* from Potter Creek Cave, California; and are also much larger than the largest specimens of the Recent Alaska bears available for study. In all elements present the form is nearer to that of *Arctotherium* than it is

to that of *Ursus*, and the type seems definitely referable to *Arctotherium*. This individual differs from all of the specimens of *Arctotherium simum* available for study in the greater width and general robustness of the metacarpal elements. This is particularly true of metacarpal four, in which the shaft is relatively very wide, and shows but little median constriction. The rugosities on all of the elements are very pronounced, indicating that this individual was probably in advanced age.

Even when the element of age is taken into consideration, it seems improbable that this form could be classed in the same specific group with *Arctotherium simum*, of which no specimens in the collection from Potter Creek Cave are found to approach the Rancho La Brea form in size and robustness.

The tooth and foot specimens were obtained from two localities so far apart that there can be no possible suggestion that they represent the same individual. As both specimens have the characters of *Arctotherium*, and both represent an extraordinarily large and robust form, it is desirable for the present to refer to the Rancho La Brea type as a distinct species, which may be known as *Arctotherium californicum*. The elements of the foot, no. 17754, are taken as the type of the species.

Like the lion of Rancho La Brea, the bear described above represents one of the largest and most powerful known carnivores of Pleistocene time. The measurements of the specimens available are as follows:

METACARPALS, No. 17754

Metacarpal I, greatest length	86.8 mm.
Metacarpal III, greatest length	126.7
Metacarpal III, least transverse diameter of shaft	18.7
Metacarpal IV, greatest length	130.5
Metacarpal IV, least width	23.
Metacarpal V, greatest length	130.2

INFERIOR CANINE, No. 10600

Distance from tip of crown to base of enamel on posterior border	47.3 mm.
Anteroposterior diameter of crown 35 millimeters below tip	26.8
Transverse diameter of crown 35 millimeters below tip	21.4

A single metapodial from the collections obtained at Rancho La Brea resembles in form and dimensions the corresponding bone of *Arctotherium simum* from Potter Creek Cave.

Transmitted February 1, 1911

THE FAUNA OF RANCHO LA BREA

PART I. OCCURRENCE

INTRODUCTION

O F THE numerous occurrences of animal remains representing
prehistoric life on the North American continent, the lo-
cality at Rancho La Brea furnishes one of the most nearly
complete pictures of the fauna of a given region at a given period
that has thus far been obtained. When all of the data have been
gathered through intensive study of this field, and when the facts
thus assembled have been interpreted, we shall have gone far
toward reaching an understanding of the biologic and climatic
conditions obtaining in the Los Angeles region during one phase
of Pleistocene time. So significant do the results of a study of
this fauna appear in relation to the general problem of the Pleisto-
cene, that it seems desirable to bring together the conclusions ob-
tained in work on all phases of the assemblage of life forms here
represented.

Since receiving the first specimens from Rancho La Brea, in
December, 1905, the Department of Palaeontology at the Uni-
versity of California has been almost continuously engaged in a
study of this most alluring field. Some of the results obtained have
already been presented in brief papers by J. F. Bovard, L. H. Miller,
W. P. Taylor, and the writer. Other articles based on material
furnished by the University have been written by Wm. J. Sinclair
and by Fordyce Grinnell. The present paper is the first of a series
of publications in which it is planned to present in full the results of
work on all of the groups represented in the Rancho La Brea fauna.
It is not to be presumed that all of the facts relating to any of the
groups discussed are yet discovered, and the writing of the last word
on the Rancho La Brea fauna will probably fall to investigators of
a later generation. It is, however, hoped that at this present stage
of progress a considerable number of the principal items of infor-

mation may be brought together; and that from these we may construct at least the foundation for more extensive work such as naturally follows any initial investigation.

In studying the fauna obtained from the Rancho La Brea Beds the writer has been assisted by many persons who have been interested in the work. Particular acknowledgment is due to Madam Hancock Ross and to Mr. Allan Hancock for their courtesy in permitting the University to carry on its excavations in this interesting field. To Mr. F. M. Anderson and Mr. W. W. Orcutt the writer is indebted for the original information which led to so many discoveries. Mr. Anderson presented his first collection to the University, and Mr. Orcutt permitted the use of his material for study.

Excepting a small part of the expense, which has been met from other funds, the financial support of the work has been generously furnished by Miss Annie M. Alexander, whose personal interest in the progress of the investigation has also been an important factor in the advancement of the work.

Dr. William Bebb of Los Angeles most generously presented to the University the first specimen of the gigantic lion found in the asphalt, and has kindly permitted the use of several important specimens of rodents in his collection.

In the course of the work Dr. Ralph Arnold, Mr. W. W. Orcutt, and Mr. A. E. Preston have greatly assisted in the interpretation of the geologic relations of the asphalt beds.

During the last year's work Mr. L. H. Miller assisted in every way possible in the direction of the excavations, and has contributed a considerable number of valuable specimens to the University. Mr. E. L. Furlong brought together some of the most valuable collections in the first two years of work, and also prepared and mounted many of the specimens. Mr. E. J. Fischer efficiently carried on the work of collection for approximately a year, and has presented several specimens obtained by him before his connection with the University. Dr. C. O. Esterly of Occidental College and Dr. F. C. Clark of the Pacific College of Osteopathy have both assisted very generously through loan and gift to the University of valuable specimens needed for study.

In bringing together such information relating to the Los Angeles asphalt beds as could be obtained from the notes of early explorers,

the writer has been much indebted to Professor Frederick J. Teg-gart and Mr. Porter Garnett for information indicating that the Rancho La Brea locality may have been visited by Gaspar de Portolá.

In connection with the study of special divisions of the fauna considered in later parts of this series of publications, the writer has been grateful for many courtesies extended. Acknowledgment of such services properly appears with a discussion of the materials especially concerned, and is reserved for mention in other parts of the series.

University of California,
    May 16, 1911

Historical

The extensive asphalt beds occurring at Rancho La Brea, on the western border of the city of Los Angeles, have been known for many years as one of the most interesting of the numerous bitumen deposits of the state, and have attracted the attention of many investigators concerned with the geology of this region.

The earliest description of bituminous deposits in the Los Angeles region known to the writer is found in the narrative of the Portolá Expedition,[1] written in 1769. In the account of the region traversed, mention is made of springs of pitch, which were observed at a stage in the journey when the party must have been in the vicinity of Rancho La Brea. While it is not possible to make certain of the exact location of the pitch springs described, a study of the route followed gives good reason for suspecting that the locality was actually Rancho La Brea.

Tar pools in the vicinity of Los Angeles were mentioned by Blake[2]

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[1] Diary of Gaspar de Portolá during the California Expedition of 1769–70. Edited by Donald Eugene Smith and Frederick J. Teggart. Publ. Acad. Pacif. Coast Hist., vol. 1, p. 53, October, 1909.—"The 3rd (August 3, 1769), we proceeded for three hours on a good road; to the right of it were extensive swamps of bitumen which is called *chapapote*. We debated whether this substance, which flows melted from underneath the earth, could occasion so many earthquakes." Also mentioned in Diary of Miguel Costansó, Portolá Expedition of 1769–70. Edited by Frederick J. Teggart. Publ. Acad. Pacif. Coast Hist., vol. 2, p. 183, August, 1911.

[2] Blake, W. P., Pacific Railway Reports, vol. 5, Geological Report, p. 76, 1857.

in his geological report included in the Pacific Railroad Survey, though it is not clear that he referred particularly to those at Rancho La Brea.   Blake's statement is as follows:

> There are several places in the vicinity of the city (Los Angeles) where bituminous or mineral pitch rises from the ground in large quantities.   These places are known as tar springs, or pitch springs, and some of them form large ponds or lakes. One of the springs was passed on our way to the city, and was near the outcrop of bituminous shale in the banks of the creek already described.   This spring was nothing more than an overflow of the bitumen from a small aperture in the ground, around which it has spread on all sides, so that it covers a circular space about 30 feet in diameter.   The accumulated bitumen had hardened by exposure and its outer portions were mingled with sand, so that it was not easy to determine its precise limits.   It formed a smooth, hard surface like a pavement, but toward the center it was quite soft and semifluid, like melted pitch.   The central portion of the overflow was higher than its margin; and it was evident that all the hard portion had risen in a fluid state and by the heat of the sun had been gradually spread out over the surface; at the same time being constantly exposed to dust, it had become so thoroughly incorporated with it that the compound had all the consistency of an artificial mixture.

In 1865 J. D. Whitney, then state geologist, in writing his report on the general geology of the Los Angeles region, gave a brief discussion[3] of the asphalt exposures and tar pools.   He referred in his report to the "very large amount of the hardened asphaltum mixed with sand and the bones of cattle and birds which have become entangled in it," but did not state that the remains were those of extinct forms.   Whitney's discussion of these beds appears in the succeeding paragraph:

> About seven miles due west of Los Angeles is the most important of the numerous tar-springs seen in this vicinity.   It is from here that most of the asphaltum used in the town is obtained.   Over a space of fifteen or twenty acres, the bituminous material (which when seen by us, in the winter, had exactly the consistency and color of tar) was oozing out of the ground at numerous points.   It hardens on exposure to the air, and becomes mixed with sand and dust blown into it, and is then known as "brea."   The holes through which the bitumen comes to the surface are not large, few being more than three or four inches in diameter.   On removing the tarry substance from the holes, by repeatedly inserting a stick, the empty cavity was very slowly filled up again.   At one place there was a pit several yards square, and six or eight feet deep, from which the tar had been taken; but it was filled with water, at the time of our visit, in consequence of late heavy

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[3] Whitney, J. D., Geol. Surv. Calif., Geology, vol. 1, pp. 174 and 175, 1865.
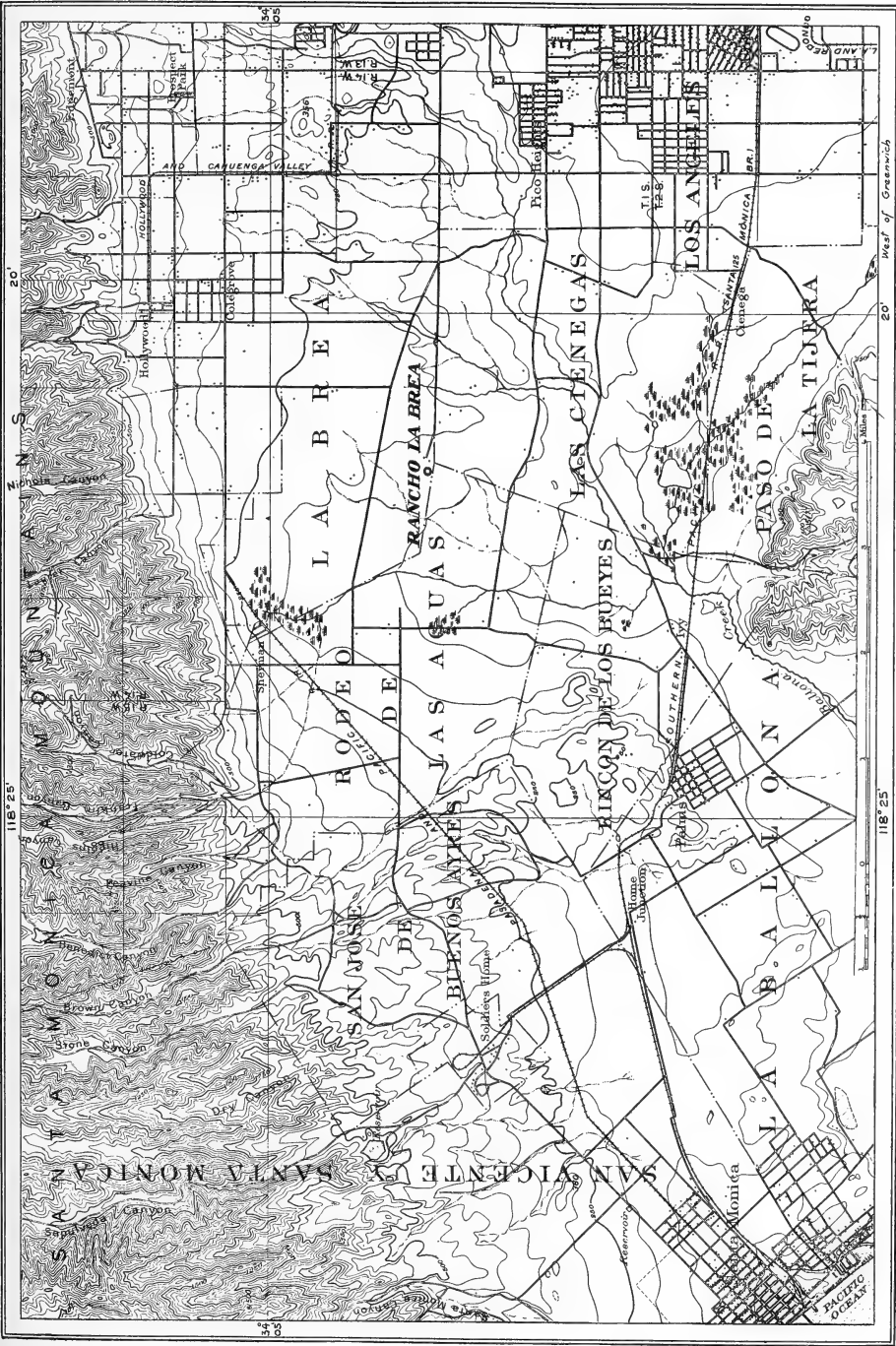
Map of region in which the Rancho La Brea Beds are situated. Adapted from U. S. Geological Survey topographic map.

rains. . . . A very large amount of the hardened asphaltum, mixed with sand and the bones of cattle and birds which have become entangled in it, lies scattered over the plain.

As nearly as can be determined, the first published statement in which reference was made to the fossil remains entombed in the asphalt at Rancho La Brea is the following issued by William Denton[4] in 1875:

The locality is known as Major Hancock's Brea Ranch, and is about eight miles west of Los Angeles, in the valley of the Santa Anna. The bed of asphaltum here covers sixty to eighty acres, and at a depth of thirty feet no bottom has been reached. Thousands of tons have been removed for roofing, paving and combustion, but the supply is almost inexhaustible.

Major Hancock had about twenty-five Chinamen employed in digging out the best of the asphaltum, which is soft enough to agglutinate in the heat of the sun. The material was conveyed to large, open iron boilers, in which it was boiled for twenty-four hours, and then run into sand molds; subsequently it was broken up, for it is quite brittle after being thus boiled, carted for nine miles and shipped to San Francisco, where it was sold for twenty dollars a ton for making asphalt pavement. The bed is about three miles south of the Santa Monica range of mountains, and it appears to lie parallel with them.

Beds of petroleum shale of tertiary age, having in many places a thickness of about two thousand feet, are to be found along the California coast, and at some distance in the interior; they are said, by Professor Whitney, to extend from Cape Mendocino to Los Angeles, a distance of about four hundred and fifty miles. They are exposed in cliffs on the coast near Santa Barbara and Carpinteria, and other places. This shale, there is good reason to believe, is the deposit from which all the asphaltum of California has been derived.

Although this shale is not exposed in the vicinity of the Brea Ranch, it is exposed in various localities at but a short distance, and doubtless underlies the asphaltum deposit, for hundreds of "tar-springs" exist in the vicinity, from which the material is still flowing over the surrounding locality, the springs being in some cases elevated, by its deposition around them, several feet above the surrounding level.

Major Hancock presented me with what I found to be a canine tooth of a Machairodus, a great saber-toothed feline. It was found at the depth of fifteen feet in the asphaltum. The tooth is nine and a half inches in length, measured along the curve, and the breadth of the crown at the base is an inch and three-quarters, being larger than any tooth of the European Machairodus, whose measurement I have been able to find. The crown of the tooth is broken, and its entire length could not have been less, I think, than eleven inches. The tooth from the Val d'Arno, in Italy, referred to by Falconer in his Palaeontological memoirs, measures eight and one-half inches in length, and the breadth of the crown at the base is one and one-half inches, while the tooth found by McEnery in Kent's Hole,

[4] Denton, Wm., Proc. Boston Soc. Nat. Hist., vol. 18, p. 185, 1875.

England, is six inches in length, and one and one-fifth inches in breadth. The California tooth is closely serrulated on both the concave and convex sides. It seems to have been exposed to the action of the elements for a long time, and contains a number of fractures, some of which have been united by the asphaltum in which it was imbedded.

I obtained a number of teeth of the fossil horse, and bones of the deer, a large bovine animal, the otter, seal, albatross, and other animals. I found near the pit a portion of the right upper jaw of the fossil horse, containing four molar teeth, or three premolars and one true molar. The first premolar is smaller in proportion to the size of the other teeth than those of the recent horse, judging by several with which I have compared it, and smaller than those of the fossil horse of India. It is but one inch in length, and three-quarters of an inch in breadth; but the other three teeth are larger than the average of the recent horse. The Machairodus tooth, with several from the fossil horse, were exhibited.

Denton considered the asphalt to be derived from petroleum shales of Tertiary age which were known to be exposed at localities near by, and were presumed to lie beneath the asphalt deposits. Evidence of this was found in the presence in this region of hundreds of tar springs from which the tar was still flowing over the surrounding areas, the springs being in some cases elevated to a height of several feet above the normal level of the ground by deposition of bituminous material.

The first fossil specimen from the asphalt mentioned by Denton is a canine tooth of a large saber-tooth cat, the tooth having been presented to him by Major Hancock. The presumption is therefore that Major Hancock was the first person to take particular notice of the fossil remains in the asphalt.

The saber-tooth canine was stated to have been found at a depth of fifteen feet in the asphaltum, so that no question could arise as to its belonging in the asphalt formation. This tooth was compared with *Machairodus* of Europe, but seemed to represent a larger animal.

Denton also obtained bones and teeth of a fossil horse, and bones considered to represent the deer, a large bovine animal, the otter, seal, albatross, and other animals.

As nearly as can be determined, no other investigator seems to have followed up the work of Denton, which was quite forgotten; and for many years past the great quantities of bones scattered about the refuse heaps, and exposed in the old quarries, have been considered as representing nothing more than remains of domestic and other animals of this region, which had been trapped in the tar in comparatively recent time.

During the past twenty years the writer has heard frequent mention of bones present in the asphalt deposits, but has always been assured that the remains were unquestionably those of Recent animals, mainly cattle and horses which had been mired in the tar.

So far as the writer has been able to learn, since the discovery by Denton, Mr. W. W. Orcutt of Los Angeles was the first person to recognize the remains at Rancho La Brea as evidently fossils, or as belonging to a geological period preceding the present.   In December, 1905, Mr. F. M. Anderson visited the Rancho La Brea beds with Mr. Orcutt, and procured a number of fragmentary specimens, including a portion of a saber-tooth skull, several teeth of the great wolf, and a number of dermal ossicles of a ground-sloth.   These specimens Mr. Anderson very kindly placed at the writer's disposal.   Realizing the importance of the discovery, the locality was visited by the writer, in company with Dr. Ralph Arnold and Mr. A. E. Preston, soon after seeing Mr. Anderson's material. With the assistance of Dr. Arnold and Mr. Preston a small collection of typical specimens was brought together.   It was upon this material, together with that presented by Mr. Anderson, that the first descriptions of remains obtained from these deposits were based by the writer.[5]

Some months after the first visit, the field was examined again by the writer under the guidance of Mr. Orcutt, who furnished much valuable information concerning the geologic relations of the region.   Regular collecting was begun soon after this, and has been carried on by the University of California since 1906. The total amount of field work aggregates about fifteen months of continuous excavation.

Immediately after the first specimens from Rancho La Brea had been examined by the writer, application was made to the owner of the property for permission to carry on excavations for scientific purposes, and Madam Hancock Ross very graciously allowed the University to take up the work at that time.

Description of the Type Locality

The fossiliferous asphalt deposits for which the name Rancho La Brea Beds has been used were so designated from their occur-

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[5] Merriam, J. C., Science, n. s., vol. 24, p. 248, 1906.   See also Bovard, J. F., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 157, 1907.

rence at Rancho La Brea, on the western side of the city of Los Angeles. The exact situation of the typical locality is as follows: SW $\frac{1}{4}$, sec. 21, T. 1 S, R. 14 W, San Bernardino Base and Meridian. At this place excellent exposures are seen within a radius of a few hundred yards of a small lake near the old Hancock ranch house. The best exposures are found in the banks bordering several extensive open cuts made by Major Hancock many years ago in excavating asphalt for commercial purposes. The lake or lagoon and several small ponds in the vicinity occupy depressions formed in mining asphalt. The work done by Major Hancock in exposing extensive areas of the brea beds, and thus making them easily accessible for examination by geologists and palaeontologists, has been in a large measure contributory to the advancement of our knowledge of this region, as otherwise the fossil-bearing beds might easily have escaped notice.

The Rancho La Brea Beds lie in a wide stretch of slightly rolling country immediately to the south of the abrupt southern slope of the Santa Monica Range. The typical exposures are situated about two and one-half miles from the southern base of the range, and are about two hundred feet below the level from which the mountains rise abruptly.

In the region immediately about the type locality asphalt is exposed in many places, and is evidently only a short distance below the surface over an area at least as large as that in which it actually outcrops. At many points in this region tar springs or seeps pour out considerable quantities of bituminous material. The flow from these seeps is fairly regular in some cases, but at other points more or less irregular exudation occurs through small crater-like vents. The phenomena of extravasation of bituminous products are seen to best advantage in the immediate vicinity of the lagoon or lake, where tar springs and tar seeps are readily discovered. In addition to the outflow of the heavier substances, large quantities of gas may be observed coming up through the water of the lake in great bubbles.

Estimates of the probable extent of the territory in which asphalt beds lie at or near the surface have been made by several persons familiar with this region. The approximations range from about a square mile down to one-fourth of a square mile. The probabilities seem in favor of making the estimate too low rather than too high.

Nature and Origin of the Rancho La Brea Beds

The formation in which the fossil bones occur at Rancho La Brea is essentially an alluvial accumulation consisting mainly of beds of clay, sand, and asphalt. In some places bedding planes are quite distinctly shown, especially in the clay or sand strata. At other localities the deposit has been irregular or in pockets, and minor local movements of the asphalt or clay masses have possibly increased the irregularity of the beds. The asphalt may occur as a nearly pure bituminous deposit, though it is usually mixed with sand, clay, or other materials. In some places it appears as fairly definite strata, while at other points it has irregularly impregnated beds of sandy or clayey material, and no definite bedding is shown.

The thickness of the asphalt deposits containing bones has not been determined, but these beds probably extend considerably deeper than the lowest levels yet reached. A depth of at least thirty feet is recorded for the work carried on by Major Hancock, and nearly the same horizon has been attained in recent excavations.

The formation in which the asphalt appears has been penetrated by the wells in the Salt Lake Oil Field immediately to the north of the principal brea outcroppings, and seems also to be a part of a series of beds comprising a considerable thickness of sand and clay strata exposed in the hills immediately to the south. The well records of the Salt Lake Field, as described by Arnold,[6] indicate the presence of Pleistocene strata from fifty to one hundred feet in thickness overlying the Tertiary formations in which the main oil-bearing beds are found. The Pleistocene section penetrated by the oil wells comprises alluvium, clay, coarse sand, gravel, and asphalt, the deposits being apparently all of fresh-water or alluvial origin. Asphalt is well represented down to the bottom of the Pleistocene portion of the section.

The formation exposed in the low, flat ridges immediately to the south of Rancho La Brea is apparently a part of the series represented by the fossil-bearing strata at Rancho La Brea and by the Pleistocene penetrated in the oil wells of the Salt Lake Field. The ridges south of the fossil beds are considerably eroded and terraced, and it is to be presumed that the erosion which is indicated

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[6] Arnold, R., U. S. G. S. Bull. no. 309, p. 187, 1907.

occurred in Pleistocene time. It is therefore probable that the fossiliferous beds now exposed at Rancho La Brea were at one time covered by many feet of strata, which have been removed by erosion inaugurated before the beginning of the Recent epoch.

Geologists who have made a study of this region are generally in agreement that the asphalt of Rancho La Brea originates in the shale formations which underlie the Pleistocene beds. According to Arnold, Orcutt, and others who have made a special examination of the conditions in the area west of Los Angeles, the Fernando formation, which immediately underlies the Pleistocene beds of the Salt Lake Oil Field, is in this region compressed into a fold, and there are reasons for considering that the crest of this fold is more or less irregularly broken, thus offering an unusual opportunity for the escape of bituminous substances at this place. The seepage of oil and tar has presumably been in progress almost continuously during the whole period of formation of the Rancho La Brea Beds. The asphaltum deposit which has formed represents the residuum left after evaporation of the more volatile portions of the oil. In accordance with slightly varying conditions of deposition, the supply of asphalt has at times been relatively abundant enough to form the greater part of the accumulation; at other times it has sufficed only to make up a small fraction of the material being heaped up in this place.

In the earlier stages of deposition of the Pleistocene formation the quantity of oil reaching the surface would presumably be larger than in the later periods, when the thick accumulation of beds, consisting in part of asphalt, would tend to prevent the escape of bituminous substances coming up from the lower formation. During the later stages of accumulation, as at the present time, it is evident that in addition to slow seepage through the mass, a part of the oil and gas reached the surface through fairly defined channels or pipes. Through passageways of this nature, which are common at Rancho La Brea, the movement of masses of tar may take place spasmodically, the holes being apparently empty at times, and on other occasions discharging voluminously.

The mode of accumulation of the deposit is pretty clearly illustrated by the conditions now obtaining in the vicinity of Rancho La Brea. This region is at the present time a comparatively level country bordered on the northern side by the Santa Monica Range,

which rises abruptly to an elevation of about twelve hundred feet above the plain. The lowlands are traversed by a few drainage lines along which detritus is carried from the Santa Monica Range, or from the lower hills, to the east and south. At a number of localities the drainage is so balanced that water easily accumulates to form marshy spots. Tar seepages are common, and lenses of asphalt of irregular shape and thickness are continuously forming.

The relation of the formation containing the mammalian fauna at Rancho La Brea to the marine Pleistocene beds of the San Pedro Series[7] occurring only a few miles to the south is not as yet entirely clear. From Arnold's investigations it would appear that the alluvial or fresh-water Pleistocene of the Salt Lake Oil Field is nearly continuous with marine beds of upper San Pedro age. As the Rancho La Brea Beds are, so far as known, an alluvial accumulation, they are presumably not perfectly continuous with the marine San Pedro, though an oscillating shore line might cause the interdigitation of marine and alluvial lenses, or estuary conditions might give a gradation from fresh-water to marine beds. That the shore line changed its position somewhat during the deposition of the San Pedro Series is evidenced by the unconformity between the upper and lower members of this series, and by the varying nature of the deposits of the Upper San Pedro. The unconformity between the upper and lower divisions indicates considerable crustal movements.

A suggestion as to the relative age of the Rancho La Brea and San Pedro beds is perhaps to be obtained by consideration of possible relationship of the crustal movements which have affected the two groups of deposits. The series of strata at Rancho La Brea and in the Salt Lake Oil Field is presumably derived in a large measure from erosion of the Santa Monica Range immediately to the north. The abrupt southern slope of this range can hardly be explained on any hypothesis other than that it represents a fault-scarp. In the Salt Lake Oil Field the Pleistocene alluvial beds consist in general of coarser materials below and finer above, showing a gradual adjustment of accumulation to conditions somewhat similar to those obtaining at the present time. Excepting the Recent alluvium, no series of beds later than those in the Pleisto-

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[7] Arnold, R., Mem. Calif. Acad. Sci., vol. 2, 1903.

cene section penetrated by the oil wells has been observed in the immediate vicinity, and it is to be presumed that these Pleistocene beds represent the accumulation following the last important movement along the fault bordering the southern side of the Santa Monica Range.   In view of the fact that the topography of this range is considered to indicate the completion of the faulting movement at no very remote date, it is not improbable that one of the last movements occurred in the period of local changes which were taking place during the deposition of the San Pedro, or at the close of that time.   It is true that important movements have occurred in this region of the coast since the deposition of the San Pedro Series, as is evidenced by the prominent coastal terraces which have cut sharply into the San Pedro.   Terraces of importance crossing a formation apparently not to be distinguished from the Rancho La Brea Beds have also been referred to as occurring in low hills south of the Salt Lake Oil Field.   These movements have, however, been largely of an epeirogenic character.   They do not appear to have been accompanied by local faulting, and may not have changed the tectonic relations of the formations at San Pedro and in the vicinity of the Santa Monica Range.

Mode of Accumulation of the Fossil Remains

The accumulation of the remains embedded in the fossil beds at Rancho La Brea, as also their assembling in the greater number of the asphalt deposits of southern California, has evidently been controlled by conditions differing largely from those which have produced other kinds of fossil deposits.   In the excavation work which has been carried on at Rancho La Brea up to the present time, though a considerable variety of deposits has been encountered, the fossil bones are found to be almost entirely confined to beds which are either pure asphalt or consist of some other material impregnated with tar.   When pure sand or clay is present without a tar impregnation there is a conspicuous absence of skeletal remains.   While it is possible that some of the impregnated strata may have received their bituminous content since the bones were deposited, the facts of occurrence seem to indicate quite clearly that the presence of tar is the condition which has controlled the accumulation of skeletal remains.

The manner in which tar or asphalt pools may catch unsuspecting

animals of all kinds is abundantly illustrated at the present time in many places in California, but nowhere more strikingly than at Rancho La Brea itself, where animals of many kinds have been frequently so firmly entrapped that they died before being dis- covered, or if found alive were extricated only with the greatest difficulty. As seen at this locality, the tar issuing from springs or from seepages is an exceedingly sticky, tenacious substance which is removed only with the greatest difficulty from the body of any animal with which it may come in contact.   Small mammals, birds, or insects running into the soft tar are very quickly rendered help- less by the gummy mass, which binds their feet, and in their strug- gles soon reaches every part of the body.   Around the borders of the pools the tar slowly hardens by evaporation of the lighter constituents until it becomes as solid as an asphalt pavement. Between the hard and the soft portions of the mass there is a very indefinite boundary, the location of which can often be determined only by experiment, and large mammals in many cases run into very tenacious material in this intermediate zone, from which they are unable to extricate themselves.

Judging from reports of the earliest observers who examined the tar seeps at Rancho La Brea, some of the pools were many feet in diameter in their natural state, and might easily in the course of years have caught a great number of even the largest mammals.

In the natural accumulation of remains at the tar pools through accidental entangling of animals of all kinds, it is to be presumed that a relatively large percentage of the individuals entombed would consist of young animals with insufficient experience to keep them away from the most dangerous places, or with insufficient strength to extricate themselves.   There would also be a relatively large percentage of old, diseased, or maimed individuals that lacked strength to escape when once entangled.   In the census of remains that have been obtained up to the present time the percentages of quite young, diseased, maimed, and very old individuals are cer- tainly exceptionally large compared with what has been seen by the writer in average collections of remains of similar animals accu- mulated under other conditions.

In addition to the natural accumulation of animal remains through the entangling of creatures of all kinds by accidental en- countering of the tar, it is apparent from a study of the collections

obtained that some extraordinary influence must have brought car-
nivorous animals of all kinds into contact with the asphalt with
relatively greater frequency than other kinds of animals. In all
the collections that have been examined the number of carnivorous
mammals and birds represented is much greater than that of the
other groups. A rough census of the University of California
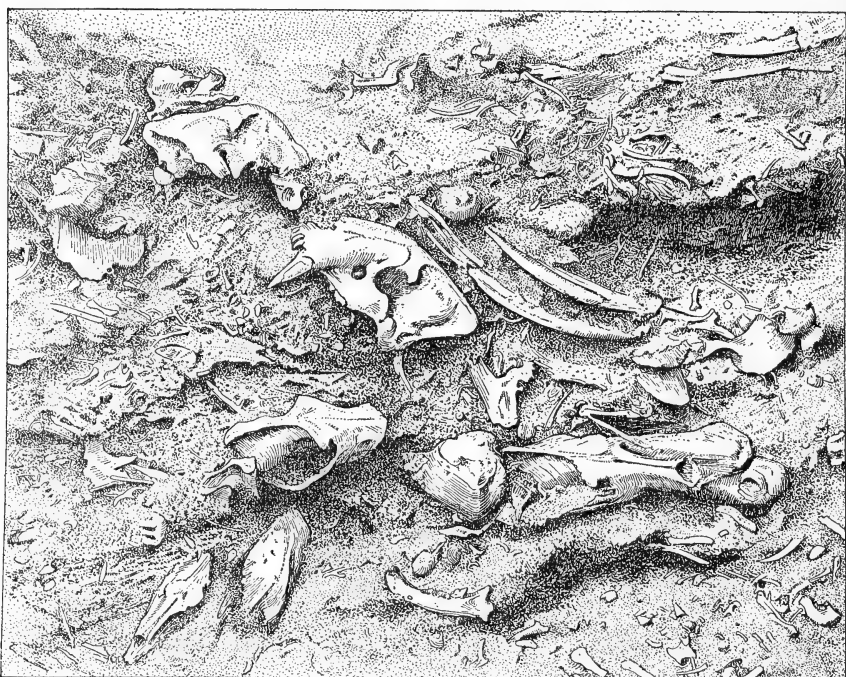mammal collection from Rancho La Brea shows more representa-

FIG. 1. A small area of asphalt in process of excavation, showing the skeletal
remains before they had been completely uncovered. In this picture there may be
seen the under side of the lower jaw of a horse, considerable parts of the skulls of four
saber-tooth cats, four large wolf skulls, two coyote skulls, and many other skeletal parts
only imperfectly exposed.

tives of the Carnivora than there are of all the other mammalian
orders combined. A similar proportion of carnivorous birds has
been noted by Miller[8] in the same collections. The number of
carnivores represented is entirely out of proportion to the normal
number of other animals present in the fauna, and is apparently to

[8] Miller, L. H., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 306, 1909.

be explained by a peculiar process of selection, which may be seen in operation about tar pools at the present time. Whenever an animal of any kind is caught in the tar its struggles and cries naturally attract the attention of carnivorous mammals or birds in the immediate vicinity, and the trapped creature acts as a most efficient lure to bring these predaceous animals into the soft tar with it. It is not improbable that a single small bird or mammal struggling in the tar might be the means of entrapping several carnivores, which in turn would naturally serve to attract still others. The suggestion that struggling animals have served as a nearly continuous lure for Carnivora seems to be the only theory by which we can explain the remarkable entangled masses of carnivore bones which have been entombed in several places. In the first excavations carried on by the University of California a bed of bones was encountered in which the number of saber-tooth and wolf skulls together averaged twenty per cubic yard. More recently in the excavations carried on by Occidental College a nearly circular depression about three feet by six feet in diameter contained thirteen individuals of the saber-tooth, lion, and wolf in a depth of eight feet.

State of Preservation and Quantity of Fossil Remains

The skeletal remains obtained at Rancho La Brea vary greatly in the state of preservation at different horizons and at different places in the same bed, but in all cases the material seems to be the practically unaltered bone. In most localities the bones are fairly hard and are easily extracted from the matrix. In other places they are very soft and can be removed only with great difficulty. At still other points the enclosing asphalt is very hard and has the appearance of having been exposed to the sun and to weathering action for a long period. In these portions of the beds the bones can be separated satisfactorily only with the aid of chisel and mallet.

As the greater number of the animals entombed in the Rancho La Brea Beds have been entrapped in the tar, it is to be presumed that in a large percentage of cases the major portion of the skeleton has been preserved. Contrary to expectation, connected skeletons are not common. Several factors have evidently combined to scatter the skeletal parts. In most localities the tangled mass of

bones shows that the tar at these points remained for a long period soft enough to engulf the bodies of animals, and during this time the struggles of each new victim tended to disturb the skeletons already in the pool.   At times when the surface of the asphalt hardened by exposure, such bones as were uncovered may have been broken or perhaps completely destroyed by ungulates tramping over the spot.   At all periods during the history of the deposit the viscosity of the asphalt apparently permitted considerable movements in the mass, and the individual bones were moved apart in the viscous layers.   These movements would continue after the asphalt beds had been deeply buried by later accumulation, as the pressure of the mass above would at times cause a certain degree of flow in the tar beds.

The pressure of the rock mass does not seem in general to have distorted the bones greatly.   Even the skulls of large animals commonly show comparatively little flattening or twisting.   Where one bone has come to rest directly against another, the weaker or softer one is sometimes dented by the harder one; but where the pressure has been exerted through the asphalt above there has usually been change of position rather than change of form.

Judging by the results of excavations carried on up to the present time, the quantity of animal remains entombed in the beds at Rancho La Brea is large.   The total area of asphalt in the region, including all of the small outcrops, probably amounts to the larger part of a square mile.   A considerable part of this area presumably contains few bones, but fragments are present in a large portion of the beds actually examined.   In most of the prominent exposures at Rancho La Brea bones are generally present, though not always abundant.   In these localities where any considerable amount of excavation work has been carried on they have usually been discovered in large quantities.

The locality at which the University of California excavations have been carried on has shown a most remarkable mass of skeletal material.   During the first stage of the excavations careful count was made of the carnivore specimens obtained, and it appeared that there were thirty or more skulls of *Smilodon californicus*, with fifty or more heads of *Canis indianensis*, in a mass comprising less than four cubic yards.   In addition to these skulls there were numerous remains of bison, horse, sloth, coyote, birds, and other forms.

At nearly all points where collecting has been done the skeletal material is somewhat irregularly distributed, and usually appears to be in rather small masses or pockets. The size and shape of these accumulations have presumably been dependent on the nature of the tar pools forming about the vents through which bituminous material has come to the surface.

While it is not safe to make any attempt at an estimate of the quantity of material represented in the whole area of the Rancho La Brea Beds, it is within the limits of probability to say that there are still some thousands of individuals of *Smilodon californicus* and *Canis indianensis* entombed in the deposits of this region. Of other forms the number is also probably very large, though somewhat less than in the case of the Carnivora.

Date of issue, November 9, 1911
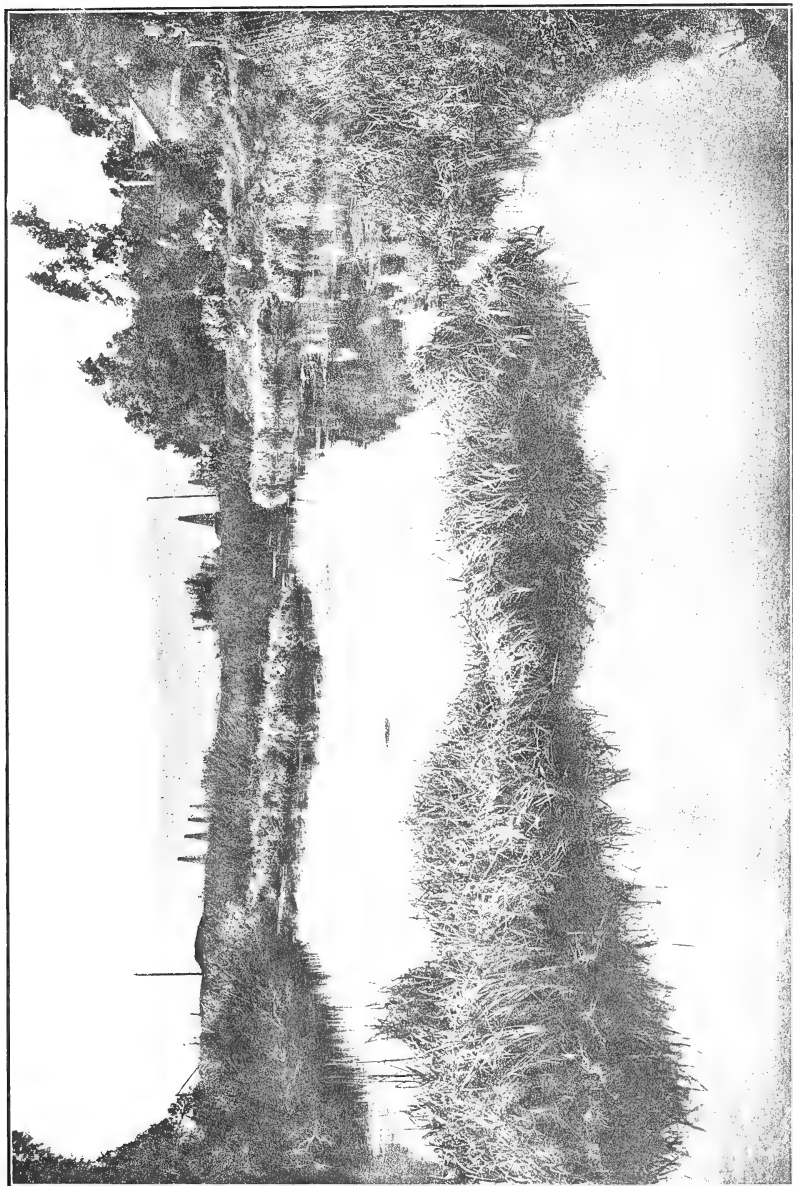
The lagoon at Rancho La Brea. The surface of the pond is streaked with oil, and gas bubbles are seen escaping through the water. The banks around the lagoon consist to a large extent of asphalt.
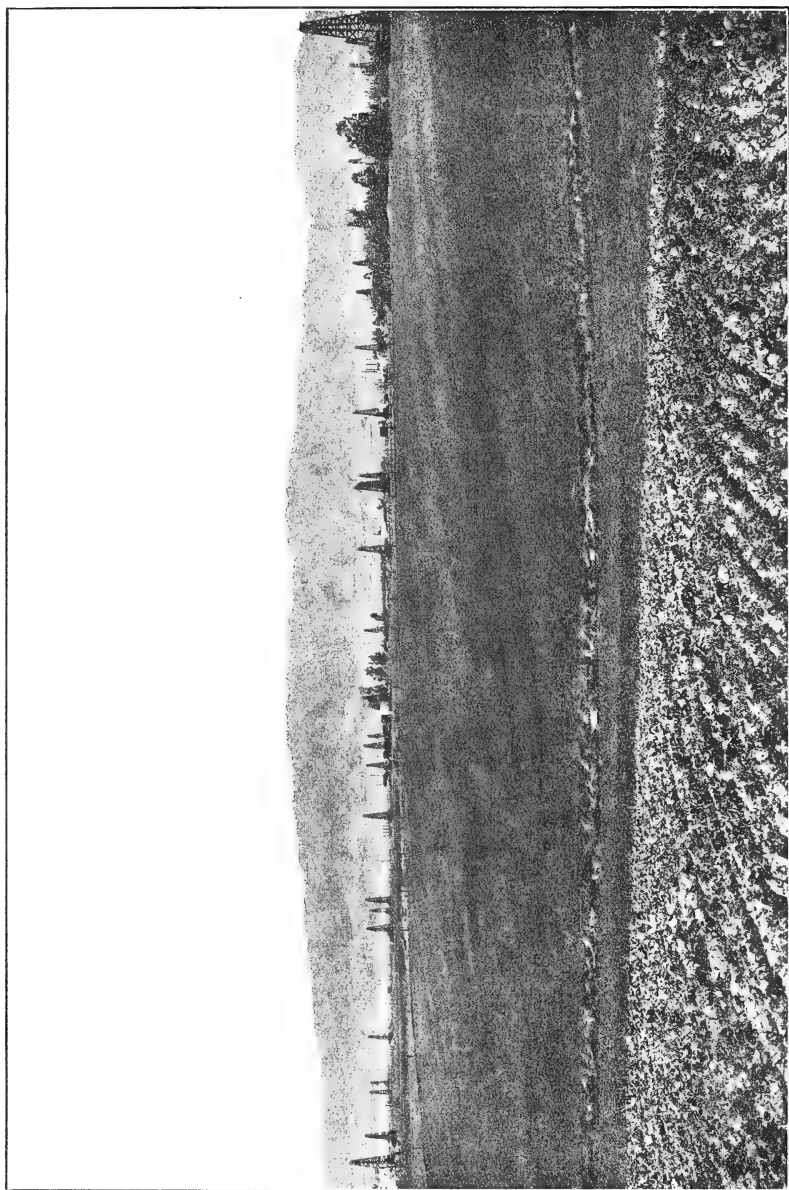
General view looking north toward the Santa Monica Range, and across the region in which the type locality of the Rancho La Brea Beds is situated. The lagoon is situated in the middle ground to the right.
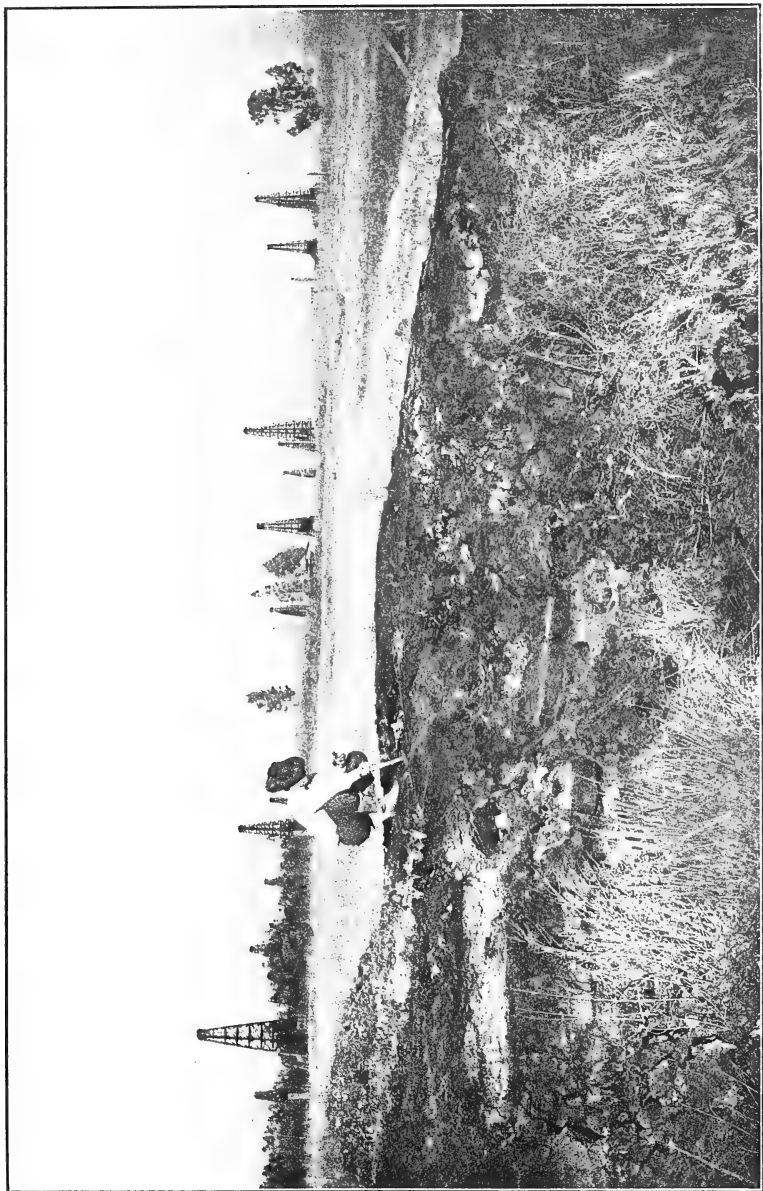
The locality at which the principal excavation work of the University of California has been carried on. The exposure to the left shows separation of distinct strata. The small white patches in the asphalt represent weathered bones still in the original matrix. Photograph by Ralph Arnold.
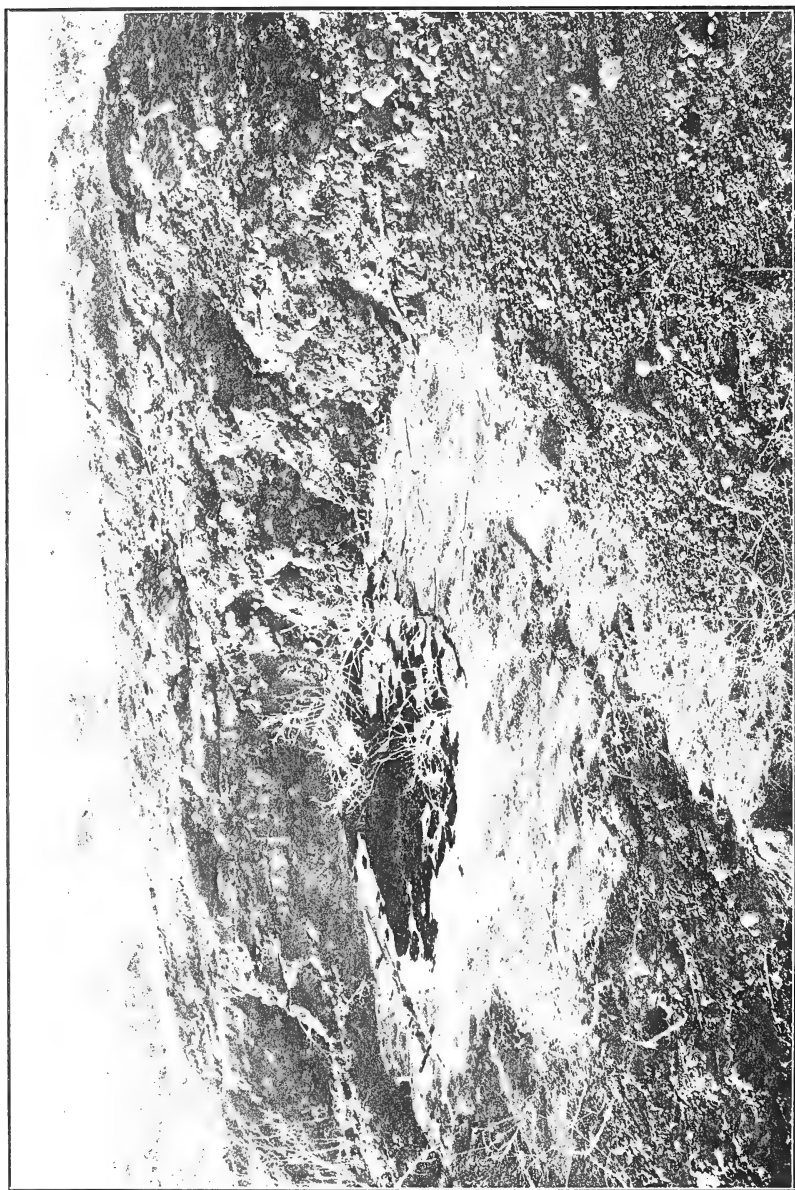
A tar seep. The area in the middle of the seep is very soft. Toward the margins the surface gradually hardens.
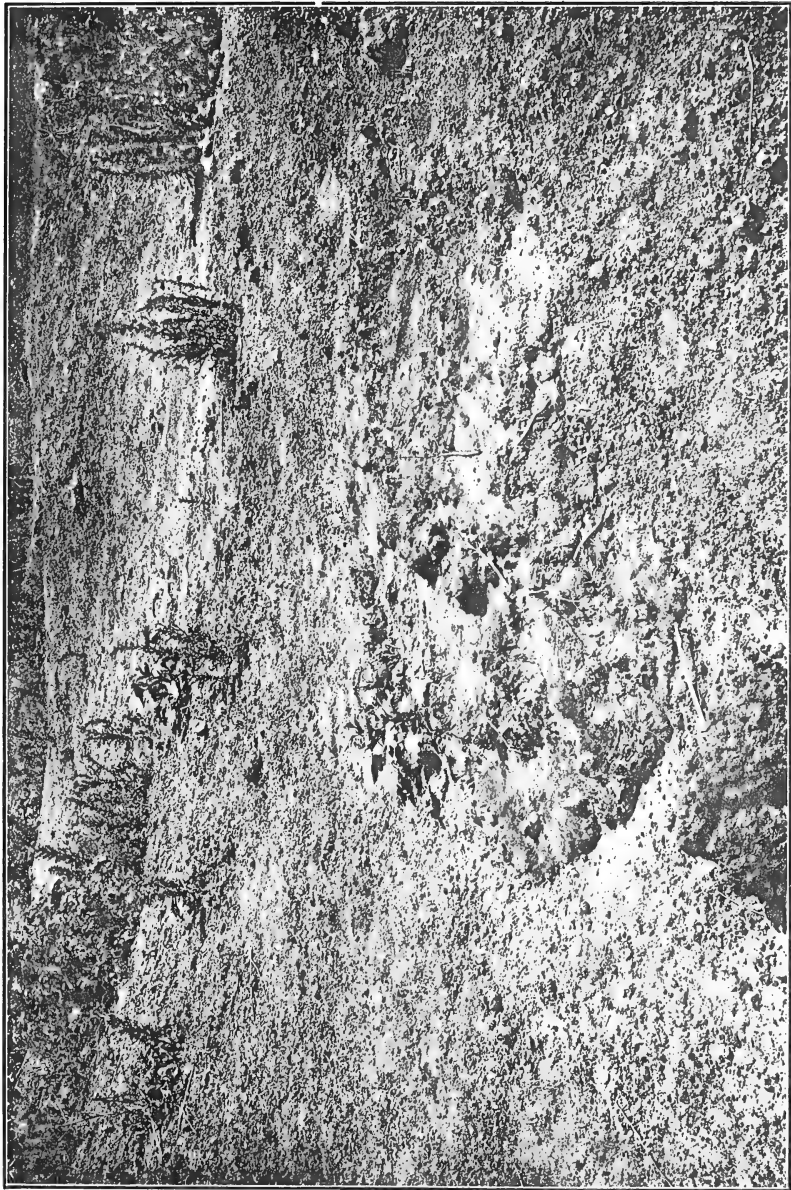
A pool of asphalt which has come to the surface through a small pipe or channel. The tar has mixed with the soil, so that its boundaries are not readily seen.

A tar seep coming up through the soil where the ground has been largely occupied by grass and weeds. Puddles and ponds of tar thus formed trap many small animals.
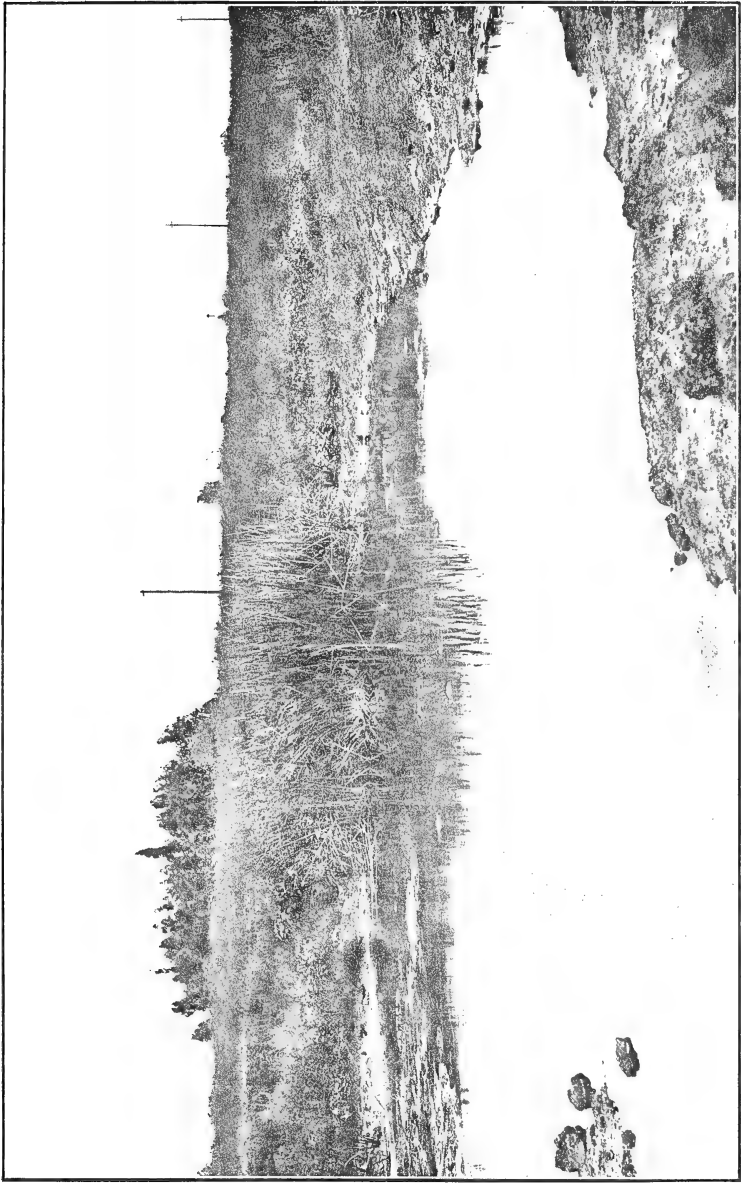
A small pond with tar seeps near the border

A tar pool in which two birds had recently been caught. The smaller one, a meadow lark, seen in the lower right-hand corner of the picture, is nearly buried in the tar.

RECENT DISCOVERIES OF CARNIVORA IN THE PLEISTOCENE OF RANCHO LA BREA

INTRODUCTION

UNTIL recently no remains of true bears and none representing cats of the puma type have been discovered in the collections of carnivore remains obtained at Rancho La Brea. Absence of these two groups has therefore been generally considered as one of the peculiar features of this fauna. Bears of the arctothere group are known from fragmentary remains representing a large species which has been tentatively designated as *Arctotherium californicum*.[1] True cats are represented at Rancho La Brea by the gigantic lion, *Felis atrox bebbi*,[2] and by wild-cats of the type of *Lynx californicus fischeri*.[3]

Included in collections from Rancho La Brea which have been prepared for study within the past year there are several fragmentary specimens which evidently represent a bear of the *Ursus* type, and a cat closely related to the existing pumas. These discoveries are of some significance in connection with studies on the distribution of the fauna of Rancho La Brea with reference both to time and to space, and it is therefore deemed desirable to record the information available.

URSUS, sp.

The remains referred to *Ursus* consist of an atlas (no. 12786) and fragments of other vertebrae. The atlas (figs. 1 and 2) is distinctly of the ursid type. It resembles *Ursus* and differs from *Arctotherium* in the character of the posterior opening of the vertebrarterial canal. The general form of the transverse process seems also to resemble *Ursus* more closely than *Arctotherium*, although this cannot be demonstrated as the ends of these processes are broken away.

[1] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol. vol. 6, p. 165, 1911.

[2] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol. vol. 5, pp. 291–304, 1909.

[3] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol. vol. 5, p. 394, 1910.

In such material as is available for comparison the atlas of *Ursus* differs from that of *Arctotherium* in the location of the posterior opening of the vertebrarterial canal.   In *Ursus* this opening is on the upper side of the posterior face of the transverse process; in
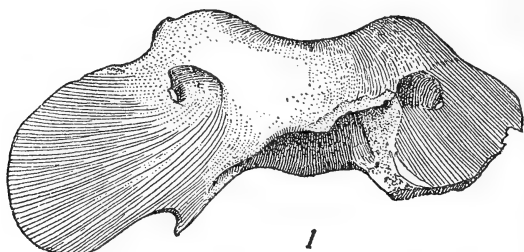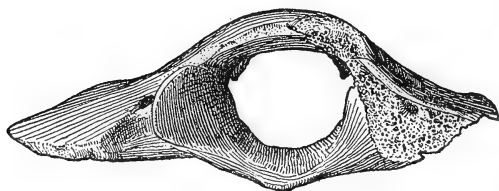
FIGS. 1 AND 2. *Ursus*, sp. Atlas. No. 12786, × ½. Fig. 1, superior view; fig. 2, posterior view. Rancho La Brea Beds.

FIG. 3. *Arctotherium simum* Cope. Atlas, superior view. No. 3035, × ½. Pleistocene of Potter Creek Cave, California.

Arctotherium (fig. 3) the posterior opening is on the upper side of the transverse process some distance in advance of the posterior margin, much as in the Canidae.   In *Ursus* the posterior articular faces of the atlas commonly extend backward on angular processes which

project some distance behind the proximal region of the posterior border of the transverse process. In *Arctotherium* the posterior border of the transverse process is slightly notched, but the plates supporting the posterior articular faces are not as prominent as they may be in *Ursus*, and there is a very narrow posterior notch. In both of the characters just mentioned atlas no. 12786 from Rancho La Brea is distinctly ursine rather than arctotherine.

The atlas may be referred to the genus *Ursus*, but specific determination is hardly possible with the material available. In form, size, and position of the posterior opening of the vertebrarterial canal the atlas specimen from Rancho La Brea is nearer to the black bear than it is to the grizzly. The form of the transverse processes differs somewhat from both black and grizzly. Unfortunately in the fossil specimen these processes are incomplete on both sides, and no distinctive characters can be based upon them.

The animal represented by the ursine atlas from Rancho La Brea was about as large as a grizzly of average size, but was very considerably smaller than the gigantic *Arctotherium californicum* known from these beds.

Measurements of Atlas

Least anteroposterior diameter on dorsal side	25.3 mm.
Greatest transverse diameter across anterior articular faces	65.5
Greatest height of neural canal	26.

Felis, near hippolestes Merriam, C. H.

The remains referred to the puma group of felines consist of a portion of a mandible and four perfect metapodials. The jaw and two of the metapodials were found near together and may represent the same individual. They agree approximately in form and dimensions with the corresponding elements of existing cougars included in *Felis hippolestes*, but it is hardly safe on the basis of such fragmentary material to assume that the species can be definitely determined.

The jaw fragment (fig. 4) is almost identical in dimensions with the average of several specimens of *Felis hippolestes*, but differs slightly in the shape of the coronoid process from the normal form in this species. In most specimens of *F. hippolestes* a line drawn between the middle of the posterior side of the condyle and the most posterior part of the upper region of the coronoid process will lean

forward. In the specimen from Rancho La Brea such a line is tipped strongly backward. This is generally considered as a characteristic of the tiger, and is a feature of all specimens of *Felis atrox* thus far examined. In the Rancho La Brea specimen the character just mentioned is coupled with distinctly greater antero-posterior diameter of the upper portion of the coronoid process. This deviation from the form of *F. hippolestes* is, however, so slight that it may have no real taxonomic value.
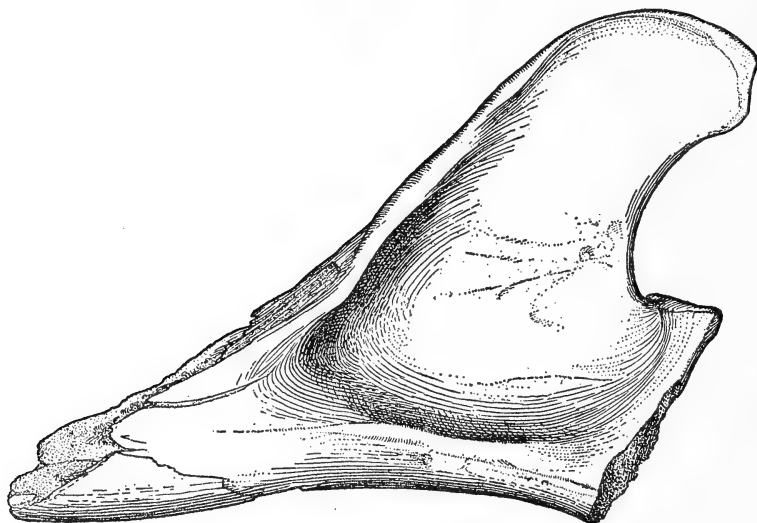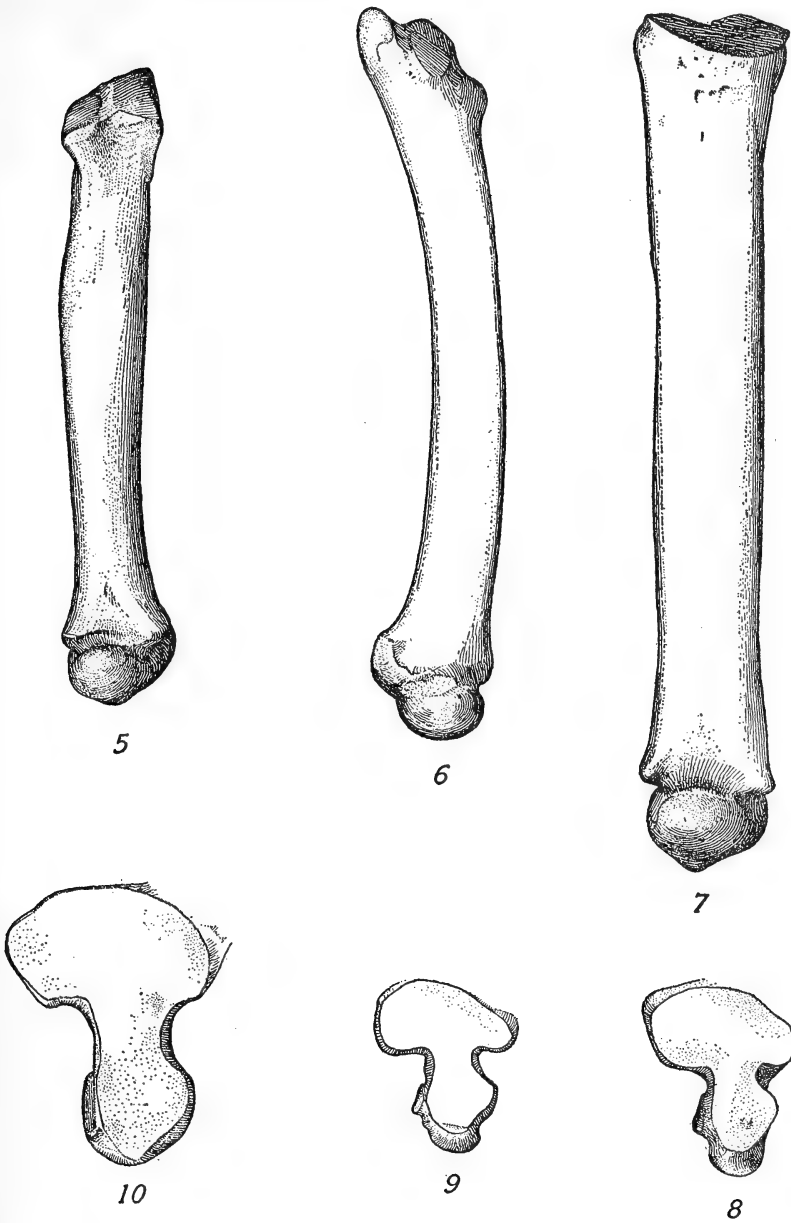

FIG. 4. *Felis*, near *hippolestes* Merriam, C. H. Fragment of mandible. No. 19525, natural size. Rancho La Brea Beds.

Of the metapodials representing the small *Felis* form, metacarpal four (fig. 5) is very slightly larger than that of an average specimen of *F. hippolestes*, but is distinguished by the character of the antero-medial region of the shaft. In the specimens of *F. hippolestes* available this area of the shaft is regularly rounded, and almost without tendency to development of an antero-medial angle. In the Rancho La Brea specimen the proximal half of this region is decidedly angular, and is swollen medially so as to produce a noticeable prominence. There is reason to doubt that this difference is due solely to individual variation.

The specimen representing metatarsal five (fig. 6) is a little larger than that of the individuals of *F. hippolestes* available. The Rancho La Brea specimen differs from the Recent ones only in greater width

FIGS. 5 TO 8. *Felis*, near *hippolestes* Merriam, C. H. Metapodials, natural size, Rancho La Brea Beds: fig. 5, metacarpal IV, anterior view, no. 19526; fig. 6, metatarsal V, anterior view, no. 12245; fig. 7, right metatarsal III, anterior view, no. 19290; fig. 8, left metatarsal III, proximal end, no. 19290. FIG. 9. *Felis hippolestes* Merriam, C. H. Proximal end of left metatarsal III, natural size, Recent, California. FIG. 10. *Felis atrox bebbi* Merriam, J. C. Proximal end of left metatarsal III, natural size, no. 12679, Rancho La Brea Beds.

of the postero-medial face for articulation, with metatarsal four, and in the more distinctly angular nature of the proximal portion of the lateral margin.

A right and a left metatarsal three (fig. 7), evidently from the same individual, are a little larger than the corresponding elements of an average specimen of *F. hippolestes*. The dimensional relations between these elements and the metatarsal five referred to *F. hippolestes* above are almost exactly similar to those between metatarsals three and five in the Recent *F. hippolestes*. The third metatarsals differ distinctly from those of *Felis atrox* and *Felis leo* in certain characters in which these two forms are alike; and in the respects in which they differ from *F. leo* and *F. atrox* they are almost identical with *F. hippolestes*.

The resemblance of metatarsal three in the Rancho La Brea specimens to the pumas, and its separation from the lions, is particularly noticeable in the form of the proximal end, and in the nature of the facets of this region. (See figs. 8 to 10.)   In the puma the roughly hammer-shaped proximal articular face shows commonly a very narrow notch on the medial side, and the posterior end of the facet terminates with a clearly-defined margin some distance anterior to the posterior tubercle of the proximal end of this bone. In the *F. atrox* and *F. leo* the medial notch is very wide and the posterior end of the proximal articular facet reaches almost to the end of the posterior proximal tubercle. In the puma the posterior lateral face for articulation with metatarsal four is entirely distinct from the proximal articular face. In the *F. leo* and *F. atrox* this face extends almost if not quite to the latero-proximal angle of the bone. In the third metatarsals (no. 19290), from Rancho La Brea, the proximal facets correspond in form to those of the puma.

The third metatarsals in no. 19290 differ in general form from those of *F. hippolestes* very slightly. They appear a little heavier anteroposteriorly in the proximal region of the shaft, and the antero-lateral side of the proximal end tends to develop a small tubercle between the proximal face and the antero-lateral face for metatarsal four. In the puma the shaft narrows gradually for some distance down from the proximal end, and there is no suggestion of a tubercle in the proximo-lateral region.

The two specimens representing metatarsal three are evidently from a form of the same type as that seen in metatarsal five and

metacarpal four described above.   This form is not separable from
the puma group by any characters thus far known.

Possible relationship of this form to the jaguar, *Felis onca*, has
been considered, but the jaw seems to differ distinctly from that
species.   No material representing the extremities of the jaguar
is available for comparison, but the nature of the mandible would
seem to suggest that the Rancho La Brea form is a puma rather
than a jaguar.   Slight differences between the elements available
and the corresponding parts of pumas at hand for comparison sug-
gest that the Rancho La Brea specimens may represent a species or a
subspecies different from *F. hippolestes*, and possibly a form as yet
undescribed.

<div align="center">Measurements</div>

Mandible

    Height from inferior margin below masseteric fossa to summit of
        coronoid process.. 64.   mm.

    Height of summit of coronoid process above condyle............ 37.

    Transverse diameter of condyle.............................. 30.8

Metacarpal IV

    Greatest length... 82.6

    Least transverse diameter of shaft........................... 9.2

Metatarsal III

    Greatest length along middle of shaft........................ 108.5

    Least transverse diameter of shaft........................... 13.

    Least anteroposterior diameter of shaft...................... 10.9

    Greatest transverse diameter of proximal end................. 19.2

    Greatest anteroposterior diameter of proximal end............ 24.3

Metatarsal V

    Greatest length... 95.6

    Least transverse diameter of shaft........................... 9.1

Conclusions

The apparent absence of arctotheres, of true bears, and of cats
of the puma group from the Rancho La Brea fauna, has appeared
to give this assemblage a distinctly ancient aspect compared with
other Pleistocene faunas in the Pacific Coast region.   There are
still many peculiar features in the life of Rancho La Brea which
make it seem quite different from that of the Pleistocene known
from other localities of this province.   Some of these peculiarities
will be interpreted as due to difference in time, and some to difference
in habitat.   The known presence of true bears, arctotheres, and
cats of the puma group brings the Rancho La Brea fauna into closer
relation with the other Pleistocene faunas of this region than had
previously seemed possible.

THE FAUNA OF RANCHO LA BREA

PART II. CANIDAE

INTRODUCTION

REMAINS of canid forms constitute a large part of the total quantity of fossil remains found in the deposits at Rancho La Brea. Thus far six species have been recognized in the fauna at this locality: these species are, *Canis dirus* Leidy; *Canis occidentalis furlongi* Merriam, J. C.; *Canis milleri* Merriam, J. C.; *Canis ochropus orcutti* Merriam, J. C.; *Canis andersoni* Merriam, J. C.; and *Urocyon californicus* Mearns. Of these forms the great wolf, *Canis dirus*, makes up more than half of the total number of specimens obtained. *C. o. orcutti*, though much rarer than *C. dirus*, is known by a considerable number of specimens. The other species are quite rare.

It is probably true that the species known from the deposits at Rancho La Brea varied to some extent in degree of susceptibility to entanglement in the tar, and therefore that the specimens found represent slightly different percentages of the number of individuals in existence during the period of deposition. It is also probable that some of the forms known were less characteristic of this region than of adjacent territory. There seems, however, little doubt that the proportion of remains of the several species obtained in the asphalt gives a fairly satisfactory approximation of the canid fauna of this region while the beds were accumulating. Though foreshadowing the fauna of the present period in the presence of a gray fox, a coyote, and a timber wolf, the difference between the canid life of this period and that of the present is emphasized in the dominance of the wolves of the *Canis dirus* type, in the presence of the peculiar short-faced *Canis andersoni*, and in the specific or subspecific difference in the coyote and the timber wolf. The gray fox, the only canid of the Rancho La Brea fauna which does not

seem to differ distinctly from existing species, is known by very few specimens.

Canis dirus Leidy

Plates 24 to 28; text figures 1 to 26

Canis primaevus Leidy. Proc. Acad. Nat. Sc., Philad., 1854, p. 200. Jour. Acad. Nat. Sc., Philad., 1856, ser. 2, vol. 3, p. 167, pl. 17, figs. 11 and 12. (Not *C. primaevus* Hodgson, 1833.)
Canis dirus Leidy. Proc. Acad. Nat. Sc., Philad., 1858, p. 21.
Canis indianensis Leidy. Jour. Acad. Nat. Sc., Philad., 1869, p. 368.
Canis indianensis Leidy. Geol. Surv. Terrs. vol. 1, Fossil Vertebrates, 1873, p. 230, pl. 31, fig. 2.
Canis mississippiensis Allen. Am. Jour. Sc., ser. 3, vol. 11, p. 49, 1876.
Canis lupus. Cope and Wortman, Indiana Geol. and Nat. Hist., 14th Ann. Rep., part 2, p. 9, 1884.
Canis indianensis. Cope, E. D., Jour. Acad. Nat. Sc., Philad., 1895, ser. 2, vol. 9, p. 453, pl. 21, figs. 14 to 16.
Canis indianensis. Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, p. 288, 1903.
Canis indianensis. Freudenberg, W., Geol. u. Palae. Abh., N. F., Bd. 9, Heft 3, S. 22, 1910.
Canis indianensis. Merriam, J. C., Mem. Univ. Calif., vol. 1, no. 2, p. 213, 1911.

Type specimen, an upper jaw with the cheek teeth, now in the collection of the Academy of Sciences, Philadelphia. Type obtained from Pleistocene beds on the Ohio River near Evansville, Indiana.

The forms referred to this species include some of the most remarkable known representatives of the Canidae, and deserve particular mention with reference to structure, geological occurrence, geographic range, and taxonomic position. Up to the time of discovery of the deposits at Rancho La Brea this wolf was known only by very fragmentary remains, and the literature contains no adequate description of any phase of its structure.

Canis dirus is the most abundant and most important of the canids from Rancho La Brea, and was evidently the dominant type of wolf in this region at the time of deposition of the asphalt beds. This species includes the largest individuals of the *Canis* group known from America. Some of the specimens exceed in dimensions all the largest known Recent wolves. Other individuals are

considerably smaller than some of the large northern wolves of the present day. The skull is especially large, and the head seems to have been relatively large compared with the limbs. The teeth are very massive, but those regions of the cheek-tooth dentition constructed especially for crushing are relatively small.

The comparatively light limbs and very massive head show that the animal was not as well developed for running as the timber wolves and coyotes. The massiveness of the dentition without corresponding development of the crushing surface indicates use of the teeth in smashing large bones. The form of the skull suggests that the head was normally held low and was often used in hard pulling and hauling of heavy bodies. The great number of individuals of *C. dirus* found at Rancho La Brea suggests that the wolves of this species sometimes associated themselves in packs, and that groups of considerable size may have assembled to kill isolated ungulates and edentates. Particularly the young, aged, and injured, when they could be separated from their associates, would be the natural prey of the great wolf, but adults in normal strength may also have succumbed to the combined attack of several of these powerful animals.

History of Literature on Canis dirus

In 1854 Dr. Joseph Leidy[1] described from deposits occurring on the banks of the Ohio River, a short distance below Evansville, Indiana, a collection of fossil bones including the remains of *Megalonyx jeffersonii*, *Tapirus haysii*, *Equus americanus*, *Bison americanus*, *Cervus virginianus*, and a large wolf. The wolf remains consisted of an almost complete left maxillary containing all but one of the cheek teeth. The species represented seemed to Leidy to vary far enough from any existing form to require a distinct specific designation, and was accordingly described as *Canis primaevus*. Leidy realized that others might fail to recognize the species as distinct, as is indicated in the following statement taken from his paper: "Certain naturalists may regard the fossil as an indication of a variety only of *Canis lupus*, and of the correctness of this view I will not attempt to decide." In 1856 Leidy[2] figured and redescribed the species under the same name.

[1] Leidy, J., Proc. Acad. Nat. Sc. Philad., vol. 7, p. 200, 1854.
[2] Leidy, J., Jour. Acad. Nat. Sc. Philad., ser. 2, vol. 3, p. 167, pl. 17, figs. 11 and 12, 1856.

In a description of *Canis (Aelurodon) saevus*, published in 1858, Leidy refers to the wolf previously described by him as *Canis primaevus*, as follows:[3]

"The present extinct species is not so large as the one whose remains have been discovered in association with those of *Megalonyx*, *Tapirus*, *Equus*, etc., on the banks of the Ohio River, Indiana, to which the name of *Canis primaevus* was inadvertently applied (Proc. Acad. Nat. Sc. VII, 200; Jour. Acad. Nat. Sc. iii, 167), and which may be distinguished by that of *Canis dirus*."

In 1869 Leidy[4] again referred to the original specimen, which he had described as *Canis primaevus*, and gave to it the name *Canis indianensis*. Apparently Leidy had forgotten the reference to this form under the name of *Canis dirus* in 1858. The name *Canis indianensis* has come to be the designation for this form commonly used in the literature. The writer is indebted to Dr. O. P. Hay for the discovery that Leidy's use of *Canis dirus* for this form preceded its designation as *Canis indianensis*.

In 1884 E. D. Cope and J. L. Wortman, in describing the post-Pliocene vertebrates of Indiana,[5] reviewed Leidy's description, and after careful consideration of the measurements of the type specimen concluded that it would be impossible to admit this fossil to the rank of a distinct and well-defined species, but it appeared, in their judgment, to be but a variety which has a representative in the mountains of Oregon today.

In 1895 Cope[6], in describing a specimen representing a large fossil wolf from Texas, referred to Leidy's type specimen as representing a distinct species, *Canis indianensis*.

Previous to the discovery of *Canis dirus* at Rancho La Brea, excepting the type specimen, the only materials described which had been referred to this form consisted of two specimens from California and one from Texas. Several limb bones described from the lead region of the Upper Mississippi by Allen[7] represent a form evidently nearer to *C. dirus* than to any other American species,

[3] Leidy, J., Proc. Acad. Nat. Sc. Philad., p. 21, 1858.

[4] Leidy, J., Jour. Acad. Nat. Sc. Philad., p. 368, 1869.

[5] Cope, E. D., and Wortman, J. L., Indiana Geol. and Nat. Hist., 14th Ann. Rep., part 2, p. 9, 1884.

[6] Cope, E. D., Jour. Acad. Sc. Philad., ser. 2, vol. 9, p. 453, 1895.

[7] Allen, J. A., Am. Jour. Sc., ser. 3, vol. 11, p. 49, 1876.

and not separated from it by any characters mentioned in the original description.

The California specimens first referred to *C. indianensis* consisted of a lower jaw which Dr. Lorenzo Yates obtained from a Quaternary deposit in Livermore Valley. The Yates specimen (see fig. 25) was tentatively referred by Leidy[8] to this species.

In 1903 a fragment of a lower jaw with the canine, the sectorial, and the last premolar, obtained from an asphalt deposit in Tulare County, California, was referred by Merriam[9] to *C. indianensis*.

A fragment of a lower jaw referred to *C. indianensis* in Sinclair's report on Potter Creek Cave,[10] on a determination by Merriam, possibly represents a timber wolf or another large wolf closely related to this species.[11]

The Texas specimen referred to *C. indianensis* consisted of portions of an upper dentition, including M^1, P^3, the canine, and an incisor. It was obtained in the Equus horizon of the Tule Cañon, on Staked Plains of Texas by W. F. Cummins. Cope,[12] to whom the specimen was submitted, pointed out some differences between the teeth of this animal and those of Leidy's type, but was inclined to regard it as an individual of the same species.

So far as is known to the writer, the first mention of the occurrence of *Canis dirus* in the deposits of Rancho La Brea appears in the preliminary description of this locality by Merriam[13] in 1906.

Figures of a nearly complete skeleton and of a perfect skull of this species were used in illustration of popular articles published by Merriam in 1908 and 1909.[14]

The most recent discovery of remains of *Canis dirus* is that reported by Freudenberg[15] from Tequixquiac, Mexico. At this locality the posterior region of a skull has been found which closely resembles the specimens from Rancho La Brea.

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[9] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, p. 288, 1903.

[10] Sinclair, W. J., Univ. Calif. Publ. Amer. Arch. Ethn., vol. 2, p. 17, 1904.

[11] See page 764 of this paper.

[12] Cope, E. D., Jour. Acad. Sc. Philad., ser. 2, vol. 9, p. 454, 1895.

[13] Merriam, J. C., Science, n.s., vol. 24, pp. 248–250, Aug., 1906.

[14] Merriam, J. C., Sunset Magazine, Oct., 1908, p. 172. Also Harper's Weekly, Dec. 18, 1909, p. 11.

[15] Freudenberg, W., Geol. u. Palae. Abh., N.F., Bd. 9, Heft 3, p. 22, 1910.

Geological Occurrence and Geographical Distribution of Canis dirus

The fairly authenticated occurrences of *Canis dirus* known to the writer include Leidy's type specimen from Indiana; the material from the lead region of the Upper Mississippi described by Allen; a specimen from the Sheridan formation of Kansas, now in the American Museum; Cope's specimen from Texas; the California specimens from Livermore Valley, Tulare County, and Rancho La Brea; and the Mexican specimens described by Freudenberg. All of the material referred to *C. dirus* has been obtained from deposits held to be of Pleistocene age. There is reason for believing that the horizons at which these specimens have been found at different localities do not differ greatly, but a discussion of the time relation of these occurrences is best considered in a division of this memoir following a discussion of the fauna.

The collection of remains associated with the type specimen, including, as it does, on the one hand, such extinct forms as *Megalonyx jeffersonii*, *Tapirus haysii*, and *Equus americanus*, and, on the other hand, the Recent *Bison americanus* and *Cervus virginianus*, cannot represent other than Pleistocene time.

The Texas specimen described by Cope seems to have occurred at the same horizon as *Mylodon? sodalis*, *Elephas primigenius*, *Equus excelsus*, *E. semiplicatus*, *E. tau*, *E. major*, *Holomeniscus sulcatus*, and *H. macrocephalus*. This assemblage including the three genera *Equus*, *Elephas* and *Holomeniscus* must be considered as Pleistocene.

The lower jaw which Leidy described from Livermore Valley, California, is presumed to have been associated with a number of remains representing other mammalian forms. This material includes the type specimen of a very large cat, *Felis imperialis*, a bison referred to *Bison latifrons*, and a large camel. The presence of *Bison latifrons* may be considered as evidence of Pleistocene age, though it is uncertain how closely the specimens were associated.

The fragment of a jaw from Tulare County described by Merriam was associated with a portion of the skull of an edentate nearly related to *Mylodon*, and is presumably Pleistocene.

The material from Rancho La Brea described in the following paper is associated with a fauna which falls well within the limits of

the Pleistocene. A discussion of the definite stage of the Pleistocene represented is deferred to a later chapter, in which the evidence from various sources will be assembled.

The material from the Upper Mississippi region is held to be Pleistocene, and the Sheridan formation in which the Kansas specimen was found is generally considered to represent an early phase of the Pleistocene.

The material described from Mexico by Freudenberg seems to have been derived from the same horizon as the great lion, *Felis atrox*, as is the case at Rancho La Brea, and presumably represents a horizon near that of the Pleistocene of Rancho La Brea.

The known occurrences of *Canis dirus* show that this animal certainly roamed over a large part of the Mississippi Valley; its range extended south into Mexico, and west into middle and southern California. Until we have a more exact determination of the time relations of the beds in which this species is found, it is not possible to be certain as to contemporaneity of the occurrence in all of these regions, but such evidence as is before us indicates that the formations concerned do not differ greatly in age. It is probable that the species was at one time present in all of the regions mentioned, though the earliest and latest occurrences may have differed much in the several regions.

That the range of *Canis dirus* extended considerably beyond the territory marked out by known occurrences is probable, but it is by no means certain that it covered a region as large as that now occupied by wolves of the *C. occidentalis* group. Until we are better acquainted with the correlation problem of the American Pleistocene, it is perhaps unsafe to attach much significance to the possible absence of *C. dirus* from the Pleistocene of Silver Lake, Conard Fissure, Samwel Cave, and Port Kennedy Fissure, and its absence or rarity in Potter Creek Cave. Absence from some of these faunas may be due to difference in age of the beds, but the deposits included in this list represent a wide range of the Pleistocene, and it is not probable that all are so far removed in time from the beds containing *C. dirus* as to have missed completely the life range of that species. Some of the localities, particularly the cave regions, evidently constituted a habitat very different from that of the known occurrences of *C. dirus*, and to this difference in environment the presence or absence of the great wolf may be due in some

measure.   The faunas of Potter Creek Cave and Samwel Cave in California lived in a hilly or mountainous country covered to a large extent with forest, whereas the Rancho La Brea fauna represents the life of a plain bordering the hills.   In view of what is known, the great wolf may be presumed to represent a fauna which ranged mainly over the great plains of an area corresponding approximately to what is now the Sonoran region.   What we know of the structure and probable habits of *C. dirus* would be in agreement with such a range, as the animal seems particularly suited for preying upon some of the larger plains mammals.

Diagnostic Characters

The largest species of *Canis* known from the faunas of North America.   Form and proportions in general near those of the existing timber wolves; head relatively larger and feet relatively smaller than in the large Recent timber wolves of the *Canis pambasileus* type.   Skull attaining a length of 310 mm. or more; relatively broad across the palate, frontal region, and zygomatic arches. Sagittal crest high, inion showing an extraordinary backward projection.   Posterior extremities of nasal bones extending relatively far back.   Nasal processes of frontals relatively short.   Postpalatine foramina opposite posterior ends of superior carnassials. Optic foramen and anterior lacerated foramen close together in a common pit.   Upper and lower carnassials relatively large and massive. P^4 with reduced deuterocone, M^1 with greatly reduced hypocone, M_1 with a small metaconid, P^2 and P_2 often without posterior cusps or tubercles.

Skull

The skull in this species (figs. 1, 2, 3, and 4) is larger than the cranium of any other wolf known to the writer.   The basal length from the anterior end of the premaxillaries to the posterior side of the occipital condyles in one of the large specimens measured (no. 10856) is 282 mm.   The total length of the skull projected on the plane of the palate, including the extraordinary backward projection of the inion, may be more than 310 mm.   In spite of the great length, the width measured across the palate, between the orbits, across the postorbital processes of the frontals, and across the zygomatic arches, is relatively large, making the skull very massive.

The facial region is characterized by extraordinary backward extension of the nasal bones, which reach a short distance behind a
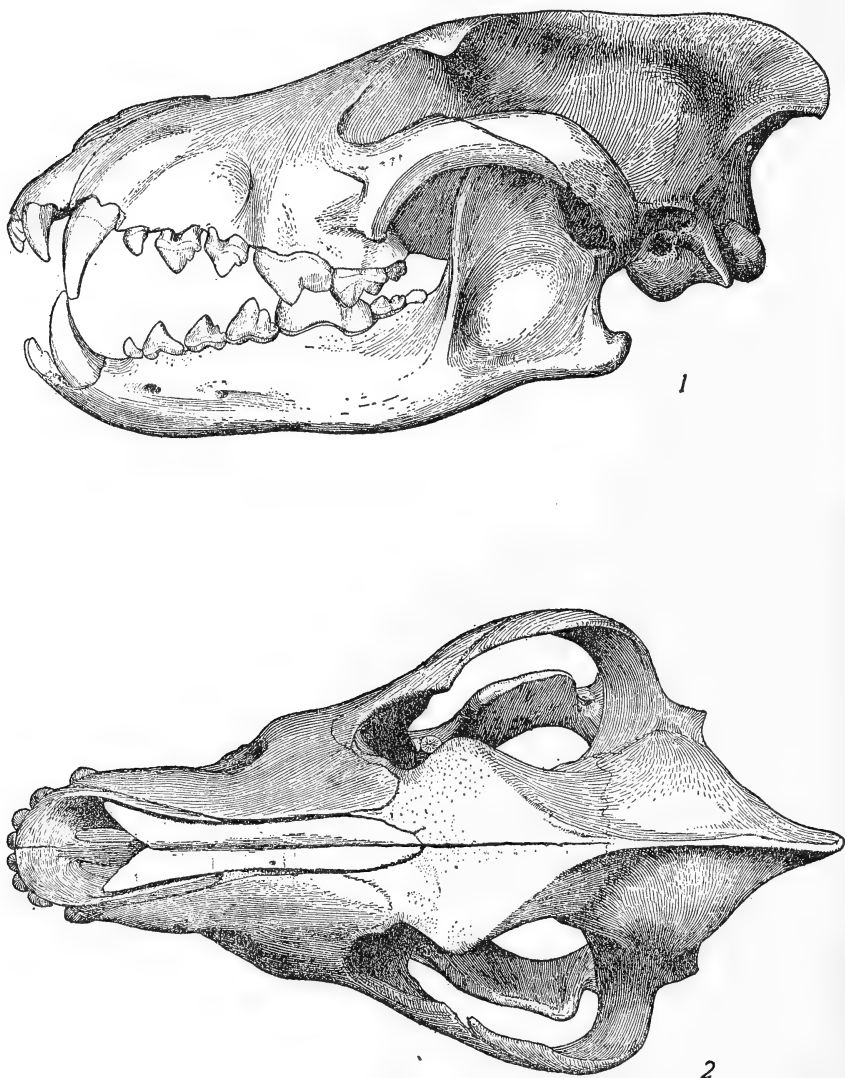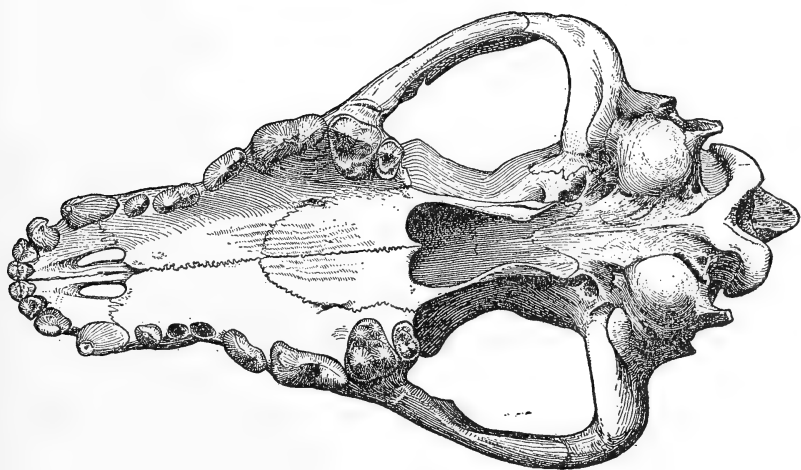

FIGS. 1 AND 2. *Canis dirus* Leidy. Skull, no. 10834, $\times \frac{3}{8}$. Fig. 1, lateral view; fig. 2, superior view. Rancho La Brea Beds.

line connecting the most nearly approaching points on the orbits. The nasal processes of the frontals are generally relatively short. In the lateral region of the face an area at the anterior root of the

zygomatic arch is generally very sharply depressed and forms a characteristic feature. On the inferior side of the zygomatic arch the attachment of the masseter muscles is very strongly marked, and ends anteriorly on a prominent knob situated at the most inferior point on the suture between the jugal and the maxillary.

FIGS. 3 AND 4. *Canis dirus* Leidy. Skull, no. 10834, × ⅜. Fig. 3, posterior view; fig. 4, inferior view. Rancho La Brea Beds.

The frontal region is relatively broad, the postorbital processes of the frontals being very largely developed. The frontal region shows only a slight median depression, which may be somewhat accentuated toward the nasal and parietal borders of the frontals. The sagittal crest is uniformly high, and is characterized especially by the extraordinary backward extension, which much exceeds that of the other wolves.

Percentages of width of the skull at various points in relation to basal length measured from the anterior end of the premaxillaries to the posterior side of the occipital condyles are as follows:

	C. dirus (a)	C. pambasileus (b)	C. latrans
Width across palate, measured between outer sides of superior sectorials...................................	38.1%	34 %	32 %
Width between most nearly approaching points on upper border of orbits....................................	22.7%	20.8%	16.5%
Width between postorbital processes of frontals..........	33.3%	27.2%	24 %
Width across zygomatic arches........................	62 %	55.6%	59.4%

(a) No. 10856. All numbers, unless otherwise noted, are from the series of the University of California Collections in Vertebrate Palaeontology.

(b) No. 984, Univ. Calif. Mus. Vert. Zool. From Susitna River, Mt. McKinley region, Alaska. This is according to Elliot (Field Columb. Mus. Publ., Zool. ser., vol. 6, p. 374) the largest Recent species of the North American wolves.

The palate is relatively broad, and the posterior palatine foramina are set relatively far back. The posterior end of the vomer extending backward between the vertical plates of the palatines commonly reaches very slightly beyond the posterior nasal opening. This is in decided contrast to the Recent wolves, in which the broad posterior end of the vomer reaches well beyond the posterior nasal opening. In most of the specimens of *Canis dirus* the posterior nasal opening is relatively wider at the anterior end than in wolves of the *C. occidentalis* type.

The occipito-sphenoidal region of the skull exhibits a tendency to shortening, the distance from the posterior border of the glenoid fossa to the posterior side of the occipital condyles averaging slightly less than in other forms. On the basal occipital the uneven surfaces corresponding to the attachment of the longus capitis muscle are marked by very rough areas which commonly do not extend as far forward as in the timber wolves. In other forms these areas extend forward for a considerable distance anterior to the tympanic bullae. In the space between the tympanic bullae and the anterior end of the inferior notch of the foramen magnum the median ridge extending from the basal occipital to the basal sphenoid is usually relatively prominent and acute, while in the timber wolves it is commonly a low, broad, horizontally truncated ridge.

The posterior aspect of the skull presents in general a very different form from that of the Recent wolves. The two ridges which form the lamboidal crest tend to converge sharply above the

occiput, while in most Recent forms they sweep outward rather widely before uniting at the inion. On the other hand, the short processes formed at the lower ends of the transverse ridges and immediately behind the superior side of the posterior root of the zygomatic arches average smaller than in the modern species. In the superior region of the occiput the two lateral depressions in

MEASUREMENTS OF SKULL

	Canis dirus (a)	Canis dirus (b)	Canis pambasileus (c)	Canis milleri (d)
Length, anterior end of premaxillaries to posterior end of occipital condyles....................	282 mm.	267	250	223
Length, anterior end of premaxillaries to anterior end of posterior nasal openings..............	155	141	131.5	119
Width across nose, measured between outer sides of bases of canines.........................	67.3	58.5	52	50.2
Width, measured between outer sides superior sectorials................................	107.5	96.2	85	89.5
Width across zygomatic arches................	175 ap	164.5	138.4	134
Least diameter between superior borders of orbits.	64.9	54.1	51	43.2
Width between postorbital processes of frontals...	93.9	77	67.7	64
Length from a line drawn between posterior borders of glenoid fossae to posterior end of occipital condyles..................................	54	57	52	52
Length, anterior end of left ramus of mandible to middle of condyle..........................	230 ap	210.5	202	178
Height of lower jaw measured between summit of coronoid process and inferior side of angle......	91.3	87	85.7	82.5
Height of lower jaw below hypoconid of M_1......	39.7	35.3	30.6	29.8
Height of lower jaw below protoconid of P_3......	36.9	32.5	31.9	24.5
Thickness of lower jaw below protoconid of M_1....	20.3	19.3	14.9	16

(a) No. 10856.　　(c) No. 984, Univ. Calif. Mus. Vert. Zool.
(b) No. 10834.　　(d) No. 11257.
ap approximate.

which the attachments of the rectus capitis posticus are situated average extraordinarily deep, and are separated by a narrow ridge which is relatively prominent with reference to the occiput as a whole. The backward projection or overhanging of the inion is extraordinary, as are also the height and thinness of the sagittal crest rising above it in posterior view.

The lower jaw tends to be relatively longer than in most wolves

and is also relatively higher and thicker below the inferior carnassial. Although the coronoid process is not unusually high, the masseteric fossa is generally very deep and rough, indicating an unusually strong muscular attachment.

Although the foramina of the skull do not in general vary greatly in form or position from those of the Recent species, certain minor modifications are usually noticeable. The posterior palatine foramina are commonly situated farther back than in the Recent American species, and are nearly opposite the posterior borders of the superior sectorials. The openings of the optic foramen and the anterior lacerated foramen are situated very near together in an uncommonly deep depression. The foramen ovale and the posterior opening of the alisphenoid canal are also situated very near together, and are usually in a distinct common depression. The situation of these foramina in this species is approximated in some of the Recent wolf species, but the openings are not often so nearly united in the Recent forms as to approach the extreme of variation here.

Permanent Dentition

Superior Dentition.—The incisors of the upper jaw (fig. 4) are not more noticeably crowded in specimens 10828 and 10856 than in the modern Alaskan wolves.

I^1 is not materially different from that in the large modern wolves. On I^2 the basal lobe on the median side is small or wanting and there is a second minute basal tubercle on the lateral side. I^3 is not materially different from the corresponding tooth in the modern wolves.

The superior canine seems to be relatively short in anteroposterior diameter at the upper margin of the enamel, its diameter slightly exceeding that of considerably smaller specimens of the Alaskan wolf. The transverse diameter or thickness is relatively large, and the tooth shows a more nearly circular cross-section. The anterointernal enamel ridge usually runs nearly straight up to the margin of the enamel, without turning backward as in Recent Alaskan wolves.

P^1 is sometimes smaller in anteroposterior diameter than P^1 of the large Recent wolves.

P^2 is relatively much smaller compared with the sectorial than in

the large Alaskan wolves, the anteroposterior diameter being about one-half that of P⁴. This tooth is frequently almost simple-crowned, as is exemplified in no. 10856, in which there is only the merest trace of a tubercle on the posterior border of the cingulum. In other cases (no. 10893) there is a distinct posterior basal cusp, and behind it a posterior basal tubercle.

P³ is also relatively small compared with the sectorial. (Ratio of anteroposterior diameter in P³ and P⁴ 19:32 in *C. dirus* no. 10856, and 16.5:24.5 in a *C. pambasileus* from Alaska.) There is a distinct posterior cusp present, and a very small basal tubercle is usually developed on the posterior border of the cingulum. The small posterior basal tubercle seems to be present more frequently than in the Recent wolves. The protocone is in general not made relatively smaller than in the Recent species through the regular addition of the posterior basal tubercle. The protocone commonly tends to be relatively large anteroposteriorly.

P⁴ is relatively large compared with all of the other premolars. The blade is massive, though not much thicker transversely in relation to the size of the skull in general than in the Recent wolves. The deuterocone is usually small, and the root supporting it does not ordinarily project as far toward the median line as in the modern wolves. Though usually distinctly set off from the protocone, the deuterocone is in some cases entirely reduced.

A peculiar feature appearing in quite a large percentage of the specimens is found in the development of a sharply angular ridge on the lower side of the cingulum on the outer side of the tritocone. The character of this ridge is in general similar to that of the lower side of the cingulum on the outer side of the upper molars. In one instance (no. 10830) this ridge is very largely developed on the left P⁴, and several distinct, rounded tubercles have arisen upon it. This last instance may possibly be attributed to pathological changes or to injury. It presents an interesting tendency of development, though it may have been stimulated by extraordinary conditions.

M¹ is relatively small both anteroposteriorly and transversely compared with the carnassial. The most noticeable peculiarity of this tooth is the reduction of the hypocone, which is smaller than in any of the Recent North American wolves. The short ridge of the hypocone never extends forward around the base of the proto-

cone to join an anterior basal ridge as commonly occurs in the Recent wolves. The extreme median side of the hypocone frequently does not extend farther toward the median line than does the base of the protocone. The protocone, paracone, and metacone are not materially different from the corresponding tubercles of the modern wolves, though the bases of the paracone and metacone often tend to be relatively thick transversely. A distinct metaconule is always present and a small protoconule is usually developed.

M^2 is relatively small compared with the sectorial, and is usually also small compared with M^1. In specimen 10856 its dimensions are practically identical with those of a Recent *C. pambasileus* which has a much smaller skull, and in which the other teeth are smaller. The principal difference between the form of this tooth seen here and that in the Recent wolves is found in the uniformly smaller size of the hypocone. In some instances the anterior end of the hypocone crest does not extend forward as a ridge of the cingulum along the anterior side of the tooth.

Inferior Dentition.—In most specimens observed the incisors are thrown considerably out of alignment by lateral crowding, I_2 being set back at least as far as I_3, while the posterior border of I_1 is nearly even with the anterior border of I_2.

I_3 has much the same form as in the large Recent Alaskan wolves excepting that the lateral lobe tends to be relatively small.

In the inferior canine the sharp anterointernal ridge which marks the enamel of this tooth takes a course somewhat different from that in the Alaskan *C. pambasileus*. In passing forward from the posteroinferior region of the inner face of the tooth it does not rise as rapidly as in the Recent Alaskan wolves, but extends forward to a point near the anterior side of the tooth and only a few millimeters above the base of the enamel before it takes a direct upward course toward the apex of the crown. The angle formed by the sharp upward turning of this ridge is higher up on the side of the tooth, and consequently more obtuse, in the Recent Alaskan forms. In a specimen of *C. latrans* from Manitoba this enamel ridge is closely similar to that in *C. dirus*.

P_1 (figs. 5, 6, and 7) tends to be rather small compared with P_2. A faint indication of an anterior basal tubercle occurs less frequently and is less distinct than in the Alaskan wolves. A faint

posterior basal tubercle is present in some instances. Ordinarily both anterior and posterior basal tubercles are absent.

P_2 in most cases shows no trace of either anterior or posterior tubercles, the tooth being as simple in form as the anterior lower premolars of *Temnocyon*. In a few cases, as in specimen 10727 (fig. 7), a well-developed posterior basal cusp is present with a minute posterior basal tubercle situated behind it.
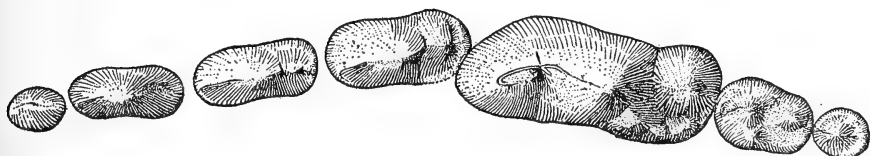
P_3 possesses a distinct posterior cusp, and a minute posterior basal

FIG. 5. *Canis dirus* Leidy. Superior view of inferior premolar and molar series, no. 10834, natural size. Rancho La Brea Beds

6

7

FIGS. 6 AND 7. *Canis dirus* Leidy. Lateral view of inferior premolar series. Fig. 6, no. 10834, natural size; fig. 7, no. 10727, natural size. Rancho La Brea Beds.

tubercle is sometimes present. The posterior shelf or heel of the cingulum may be prominent and rather sharply turned up on the posterior side as in the modern wolves; or may, as in no. 10856, be much less distinctly marked, and may slope downward from the posterior basal cusp to the posterior margin of the tooth without exhibiting any upward curvature.

P_4 is relatively large compared with P_3, but shows almost exactly the same size in relation to M_1 as is seen in the Alaskan *C. pambasileus*. The posterior cusp and posterior basal tubercle are well developed. The posterior portion of the tooth is somewhat wider than the anterior in many cases. The posterior basal tubercle is usually situated on the extreme posterior portion of the cingulum, and its posterior border is the extreme posterior margin of the tooth. In some cases, as in no. 10727, this tubercle is separated from the posterior border by a distinct notch and another small tubercle is present on the posterior margin of the cingulum.

In M_1, the trigonid portion of the tooth is generally relatively long and massive, or the heel region is relatively short compared with the large Recent wolves of North America. The metaconid is also generally smaller than in the modern species, though not always smaller than in all the Recent varieties. The hypoconid portion of the heel exhibits a tendency toward relatively greater development than the entoconid region. In nearly all specimens three small tubercles have developed in the space between the metaconid and the entoconid. One of these is usually situated on the base of the metaconid, one on the base of the entoconid, and one intermediate between the two. In some cases the number of these secondary tubercles varies above or below three, and their position may also vary somewhat from the situations indicated as most typical.

M_2 and M_3, the tubercular molars, are relatively small both anteroposteriorly and transversely in comparison with the inferior carnassial. In specimen 10856 M_2 shows an anteroposterior diameter of 12.8 mm., in comparison with 35.7 mm. in the carnassial. In the large Alaskan wolf, *C. pambasileus*, (no. 984, Univ. Calif. Mus. Vert. Zool.) the corresponding dimensions are: M_2, 12 mm.; carnassial 29 mm. In M_3 the relative reduction is still more noticeable, this tooth measuring 7 mm. anteroposteriorly in the *C. pambasileus* specimen and only 6.5 mm. in *C. dirus* (no. 10856). The reduction in M_2 is due in some cases to a noticeable weakness of the heel region. The metaconid of M_2 is in some cases reduced to a small tubercle situated on the side of the nearly central protoconid. In rare cases a small tubercle is present in the paraconid region (fig. 8). As a rule no tubercle is present to represent paraconid or parastylid (fig. 10).

A very large specimen (no. 11281) referred to *C. dirus* presents a

number of characters in which the dentition varies slightly from the typical individuals of this species. (See fig. 11.) At the same time the principal peculiarities of this specimen are those of the *C. dirus* form. P^4 is exceptionally massive, the transverse diameter of the protocone blade being relatively large. Another even larger upper carnassial with an anteroposterior diameter of 35.2 mm. (no. 12576) is relatively a little thinner transversely. In M^1 of specimen 11281 the hypocone is larger than in any other individual found. It does not, however, reach the relatively large size of the Recent American wolves, nor is the hypocone ridge extended around the anterior

FIGS. 8 TO 10. *Canis dirus* Leidy. M_2, superior view, natural size. Fig. 8, no. 19472; fig. 9, no. 19473; fig. 10, no. 19474. Rancho La Brea Beds.
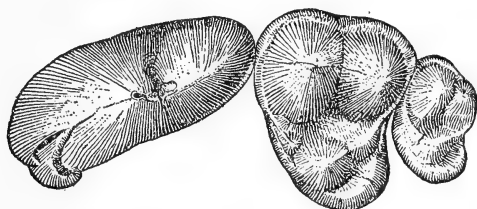
FIG. 11. *Canis dirus* Leidy. Upper carnassial and upper molars, occlusal view, no. 11281, natural size. Rancho La Brea Beds.

side of the protocone as in the wolves of the *C. occidentalis* type. In M^2 also the hypocone is relatively a little larger than in the average of the Rancho La Brea individuals of *C. dirus*. The metacone is also relatively a little larger than in average specimens from this locality, having, as in Leidy's type, nearly the size of the paracone.

A lower carnassial associated with no. 11281 also indicates an individual of gigantic size. The characters of this tooth are those of the typical *C. dirus*.

Specimen 11281 evidently belongs in the true *C. dirus* group, but represents an exceptionally large form varying from typical individuals in the nature of the hypocone of M^1.

Measurements of Permanent Dentition

	C. dirus (a) large specimen Rancho La Brea	C. dirus (b) medium specimen Rancho La Brea	Type of C. dirus	C. pambasileus (c) Alaska	C. occidentalis (d) Canada	C. dirus Sheridan formation, Kansas	C. dirus Texas specimen	C. dirus (f) Rancho La Brea	C. milleri (g)
I₃, greatest transverse diameter	...	...	...	7.6	...	...	...	...	...
C, greatest anteroposterior diameter at lower edge of enamel	17.5 mm.	...	...	15.5	...	...	...	...	...
P₁, greatest anteroposterior diameter	7.7	7.4	...	7	...	6.3	...	...	...
P₂, greatest anteroposterior diameter	15.4	15.3	...	13.5	...	14.7	...	...	...
P₃, greatest anteroposterior diameter	16.7	15.8	...	15.5	...	15.5	...	...	16
P₄, greatest anteroposterior diameter	20	19.5	...	16.5	16	19.9	...	...	18.2
M₁, greatest anteroposterior diameter	35.7	34.5	...	29	32	33.7	...	38.6	32
M₁, greatest anteroposterior diameter of heel, on outer side	9.2	8.8	...	8.2	...	8.2	...	9.3	7.8
M₁, greatest transverse diameter of heel	13.5	13	...	11	12.2	12.6	...	13.7	12
M₁, greatest transverse diameter of trigonid	14.3	13.6	...	11.8	...	13.8	...	...	13.5
M₂, greatest anteroposterior diameter	12.8	13.3	...	12.3	12.66	12.5 ap	...	...	12.4
M₂, greatest anteroposterior diameter of heel, on outer side	4.5	5	...	4.5	...	...	...	...	4.6
M₂, greatest transverse diameter	10	9.3	...	10	9	10	...	...	9.1
M₃, greatest anteroposterior diameter	6.5	7.3	...	7	...	...	...	...	5.9
I¹, greatest transverse diameter	...	...	7	...	...	...	...	...	...
I³, greatest anteroposterior diameter	12e	...	...	10.5	...	...	...	...	...
C, greatest anteroposterior diameter at upper edge of enamel	17	...	...	16.2	...	...	...	...	...
P¹, greatest anteroposterior diameter	10.2	9.4	...	8.5	...	...	...	...	...
P², greatest anteroposterior diameter	16	16.2	14.8	15	...	...	...	...	...

MEASUREMENTS OF PERMANENT DENTITION—*Concluded*

	C. dirus (a) large specimen Rancho La Brea	C. dirus (b) medium specimen Rancho La Brea	Type of C. dirus	C. pambasileus (c) Alaska	C. occidentalis (d) Canada	C. dirus Sheridan formation, Kansas	C. dirus Texas specimen	C. dirus (f) Rancho La Brea	C. milleri (g)
P³, greatest anteroposterior diameter......	19	18.1	18.2	16.5	17.33	...	18.5	...	17.5
P³, greatest transverse diameter...........	...	7.9	8	...	...	...	8	...	7.4
P⁴, greatest anteroposterior diameter......	32	30.7	32 *ap*	24.5	27	...	...	33.8	28.2
P⁴, greatest transverse diameter across deuterocone...........	16.2	15	14.5 *ap*	14	14.5	...	...	16.9	15.8
P⁴, greatest transverse diameter across protocone..............	13	13	...	11	...	...	...	15.3	12.8
M¹, greatest anteroposterior diameter......	20	18.7	18.5*	17.5	...	...	18	20	16.4
M¹, greatest transverse diameter...........	24	23	21.5	·22.5	23	...	21.3	25	20.7
M¹, transverse diameter of protocone.........	13.6	...	12.6	...	...	...	...	...	12.7
M², greatest anteroposterior diameter......	10	9.2	10	10	...	...	...	10.8	9
M², greatest transverse diameter...........	15.4	14.4	14.9‡	14	...	...	...	14.6	12.9

(a) No. 10856.
(b) No. 10834.
(c) No. 984, Univ. Calif. Mus. Vert. Zool.
(d) No. 115995, U. S. Nat. Mus.
ap approximate.
* Without posterior enamel.
‡ Without enamel.

(e) No. 10828.
(f) No. 11282.
(g) No. 11257.

Milk Dentition

The milk dentition is well shown in several specimens. In no. 10831 it presents the following characters: The superior temporary carnassial (figs. 12 and 13) has well-developed cutting blades; the inner root is situated almost directly above the apex of the protocone; there seems to have been no deuterocone present upon the base of the inner root, but there is a minute tubercle on the cingulum a short distance in advance of the base of this root, and nearer the normal position of the deuterocone on the permanent carnassial. In the inferior milk carnassial (figs. 14 and 15) the cutting blades are well-developed and the metaconid is small; on the heel the en-

toconid approaches the size of the hypoconid, and the hypoconulid is near the size of the entoconid. Dm₃ (fig. 14) possesses a large posterior cusp. A minute basal tubercle may be present on the anterior side of this tooth.

MEASUREMENTS OF MILK DENTITION

No. 10831

Dm$_3$, greatest anteroposterior diameter.... .... 8.7 mm.
Dm$_4$, greatest anteroposterior diameter...................................... 15.5
Dm$_4$, greatest transverse diameter across heel.............................. 6.6
Dm^3, greatest anteroposterior diameter...................................... 14.6
Dm^4, greatest anteroposterior diameter...................................... 10.8
Dm^4, greatest transverse diameter... 11.4
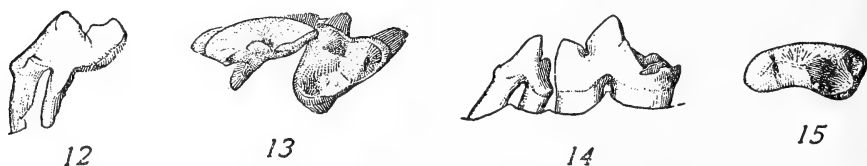
FIGS. 12 TO 15. *Canis dirus* Leidy. Milk dentition. Figs. 12 and 13, no. 19475, natural size; figs. 14 and 15, no. 19481, natural size. Fig. 12, upper milk carnassial, inner side; fig. 13, upper milk carnassial and tubercular milk molar, occlusal view; fig. 14, lower milk carnassial and preceding tooth, inner side; fig. 15, lower milk carnassial, occlusal view. Rancho La Brea Beds.

Vertebrae

Owing to the peculiar occurrence of remains at Rancho La Brea it is very difficult to obtain complete connected skeletons. The viscosity of the asphalt mass in which the bones are entombed has permitted the elements of each individual to move easily in many directions. It has therefore been found very difficult to obtain connected parts such as occasionally appear in most deposits of fossil remains. Particularly exceptional is it to find a vertebral column which is even approximately complete, and in which all of the elements can be recognized as belonging to one specimen and certainly distinct from numberless other skeletons closely packed in the matrix.

For the reasons just given it is difficult to make more certain of the vertebral formula of *Canis dirus* than to learn that the relations of the vertebrae where found in connected portions of the column, and as indicated by the fitting together of the abundant material available, show no indication of a variation in number of vertebrae from that of the modern timber wolves.

The *atlas* is rather variable in form, but resembles that of *Canis lupus* in most respects. It differs from that of *C. lupus* mainly in the more common tendency of the transverse processes to take on a triangular form. In *C. lupus*, and in the wolves generally, the transverse processes of the atlas are broad transversely, and are formed in such a manner as to give each transverse process an approximately quadrate form. In *C. dirus* the lateral margins of the transverse processes are sometimes so truncated that the form tends toward the quadrate; but in many cases the margin, beginning with the anterior notch for the vertebral artery, slopes outward and backward, so that each process tends toward a more nearly triangular form with the apex at the posterolateral angle. This form of atlas is shown especially well in figure 16.
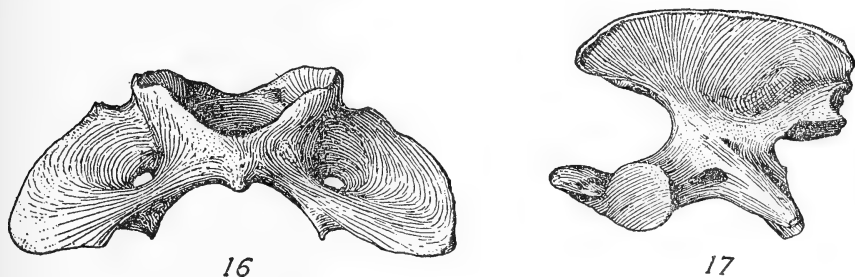
FIG. 16. *Canis dirus* Leidy. Atlas, inferior view, no. 10834, $\times \frac{1}{2}$. Rancho La Brea Beds.
FIG. 17. *Canis dirus* Leidy. Axis, lateral view, no. 10834, $\times \frac{1}{2}$. Rancho La Brea Beds.

Compared with the only specimens of *C. occidentalis* available for study, the atlas of *C. dirus* is commonly distinguished; 1) by the much larger opening of the vertebrarterial canal, which perforates the transverse process almost normal to the blade instead of perforating it obliquely; 2) by the much shallower anterior notch for the vertebral artery; 3) by the less marked tendency of the transverse processes to project behind the posterior ends of the facets for articulation with the axis.

The *axis* (fig. 17) is near that of *Canis lupus* in form. In lateral view it tends to be short and relatively high compared with most canids. Seen from below it is relatively wide. It is generally characterized by relatively short transverse processes, which often project little if any behind the posterior end of the centrum. A character which seems generally to appear in the axis of this form

is the presence of a shallow notch on each side in the postero-lateral margin of the spine between its postero-superior angle and the small tuberosities just above the posterior zygapophyses. This region of the margin is in most canids without a distinct emargination; there is, however, such a notch in the axis of *C. occidentalis.*

The cervicals from number three to number seven do not differ markedly from those of the modern timber wolves. In number three the low spinal ridge is clearly marked in all specimens examined. The postero-superior tubercles above the postzygapophyses vary considerably in size in different individuals. The anterior and posterior limbs of the transverse processes extend slightly beyond the ends of the centrum. On number five the laterally directed posterior tubercles on the transverse processes are well developed. In number six the anterior side of the blade of each transverse process is commonly rather deeply notched immediately anterior to the base of the process arising laterad of the vertebrarterial canal. The inferior side of number seven is marked by a distinct median ridge.

The *dorsals* do not differ markedly from those of *C. occidentalis.* The first dorsal is usually characterized by a relatively great transverse diameter of the postero-inferior region of the spine, and by the tendency to development of a deep longitudinal groove on this region of the spine. Dorsals three to ten are distinguished from those of some of the other wolves by the absence of notches between the anterior zygapophyses and the anterior border of the transverse process. The anterior border of the lamina in this region is usually only slight concave. The small tubercles which commonly appear immediately above the rib-articulation on the transverse processes of the third to the tenth dorsals are commonly rather small compared with those of many canids. On the twelfth and thirteenth dorsals the metapophysial processes are not distinctly separated from the zygapophyses by an antero-median notch as in some other canids, but the inner side of the metapophyses is nearly continuous with the prezygapophysial faces.

The *lumbars* are closely similar to those of the modern timber wolves. They seem generally to show the same tendency of the inner side of the metapophyses to grade into the inner face of the prezygapophyses shown in the most posterior dorsals.

The *sacrum* varies somewhat in form, being wider posteriorly in

some individuals than in others, this difference being possibly due to sex. It does not, however, seem to depart distinctly from the form seen in *Canis lupus*. The posterior extensions of the transverse processes of the last vertebra included in the sacrum commonly extend only a short distance behind the posterior articular face of the centrum, but vary somewhat in this respect. The spines of the posterior vertebrae included in the sacrum are higher than in a specimen of *C. occidentalis* available for comparison.

It is not easy to make certain of the form of the tail and of the number of vertebrae included in it; so far as can be determined, the number of *caudals* did not vary distinctly from that in *C. occidentalis*. The size of the tail as indicated by the form of the posterior region of the sacrum was not very different from that of the modern timber wolves. The individual caudal centra are not found to differ in form from those of the timber wolves.

No peculiar characters are noted in the elements of the rib-basket and sternum.

Extremities and Arches

The form and proportions of the limbs in *Canis dirus* show that it was an animal constructed on much the same lines as the timber wolves, though somewhat heavier, with the limbs lighter in relation to the head. It was probably slower-footed than the modern forms.

Anterior Arch and Limbs.—The *scapula* varies somewhat in the series of specimens available, but is in general hardly to be distinguished from that of *Canis lupus* or *C. occidentalis*, excepting in its larger size. The region of the infraspinous fossa is commonly very wide, and the area for attachment of the teres major is distinctly marked.

The *humerus* is a massive bone compared with that commonly seen in the Canidae. The deltoid ridge and the tuberosities are usually very strongly developed. The *ulna* and *radius* are both heavy elements. The ulna is not distinguished from that of the timber wolves by any sharply-marked characters. The head of the radius is, in general, relatively thick anteroposteriorly in correspondence to the anteroposterior thickness of the massive distal end of the humerus. On the distal end of the radius there is commonly only a faint groove for the tendon of the extensor ossis

metacarpi pollicis, whereas in many modern wolves and coyotes this groove and the tubercle above it are clearly marked. The small size of the groove possibly indicates weakness of the extensor muscle of the thumb. A similarly shallow groove has been noted on one radius of a specimen of *C. occidentalis*.

Study of a large series of specimens of *C. dirus* indicates that the feet are not relatively as heavy as in the large timber wolf, *C. pambasileus*. The mesopodial elements of the average specimens are of about the same size as those of a specimen of *C. pambasileus* in which the skull is somewhat smaller than in the average of *C. dirus*. Compared with the same skeleton of *C. pambasileus*, the average specimen of *C. dirus* has absolutely smaller metapodial and phalangeal elements.

In the *manus* of *C. dirus*, excepting minor differences, the form of the elements generally resembles that of the modern wolves quite closely. Among the carpals, the scapholunar seems commonly to be distinguished by the shorter transverse diameter of the medial facet of the distal side upon which the trapezoid articulates. This would seem to indicate a smaller transverse diameter of the trapezoid and a corresponding narrowing of the head of metacarpal two. It has not, however, been noted that either of these elements is markedly narrowed. The metacarpals in some cases have the shaft relatively wide anteroposteriorly in *C. dirus*. In metacarpal four the anterior medial facet at the proximal end is developed as a relatively long downwardly extended surface marked by a gentle elevation at about the middle of its length. In *C. pambasileus* this facet is shorter vertically, and the protuberance is much more prominent. In some of the other canid forms, as in the domestic dog and in the coyote, this facet does not reach as far down on the shaft.

So far as can be determined, the *pollex* is not larger, and is probably on the average smaller, than in the timber wolves. The finding of skeletons in which the elements are associated is very uncommon at Rancho La Brea, and it has been especially difficult to make certain of the association of the smaller elements of the limbs. The suggestion that the pollex was small is based on the fact that the average of the specimens of metacarpal one in the collection is relatively small, this evidence being supported by that of the small groove for the tendon of the extensor ossis metacarpi pollicis, and the small, short facet for the trapezoid.

The average of the phalangeal elements of the anterior limb in the collection is smaller than in a large specimen of *C. pambasileus.*
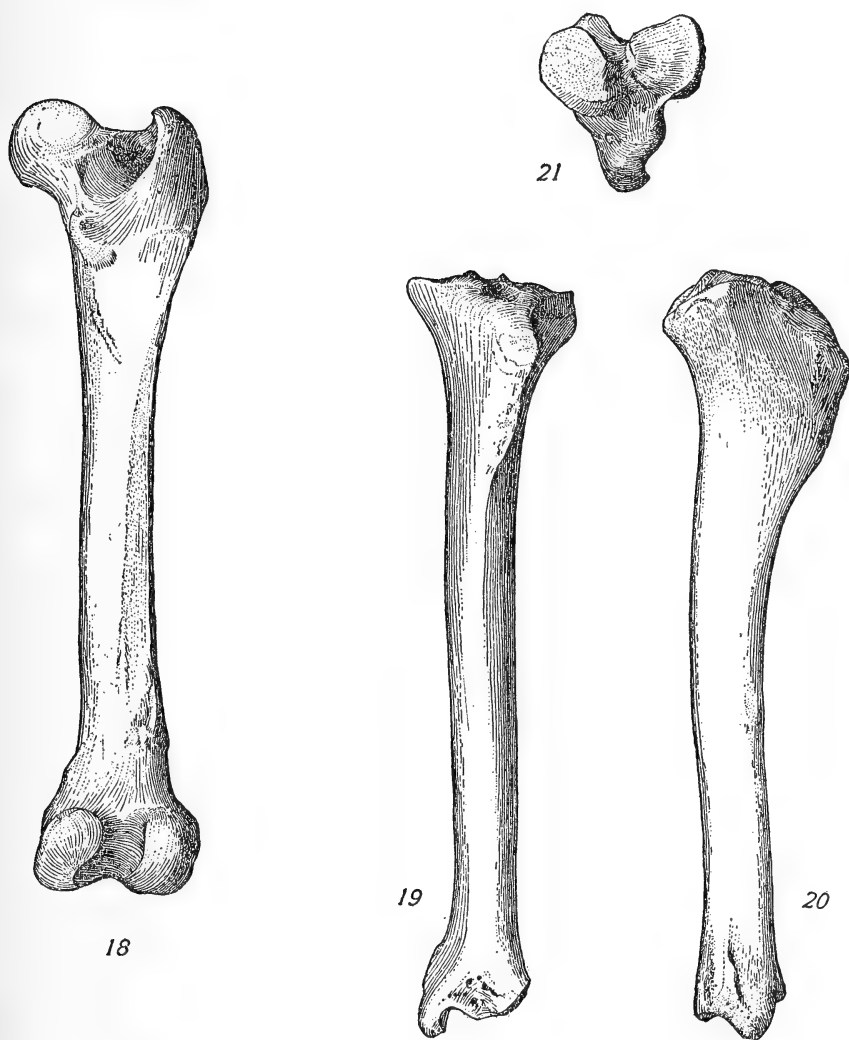

FIG. 18. *Canis dirus* Leidy. Femur, posterior view, no. 10540, × ⅔. Rancho La Brea Beds.

FIGS. 19 TO 21. *Canis dirus* Leidy. Tibia, no. 19482, × ⅔. Fig. 19, anterior side; fig. 20, medial view; fig. 21, superior view. Rancho La Brea Beds.

The terminal phalanges have stout, gently curved claw-cores, and are extended inferiorly as strong subungular processes.

Posterior Arch and Limbs.—The *pelvic arch* is closely similar to

that of the timber wolves.   In the posterior extremities the *femur* (fig. 18) varies considerably in the weight of the shaft, being in some cases heavier than in the timber wolves.   The tibia is commonly very massive.   In the femur the greater trochanter is always large in adult animals, and may project upward to a point almost level with the proximal side of the head.   The smaller trochanter and the spiral line below it are always well developed.   The tubercle on the postero-lateral region of the shaft just above the popliteal surface is usually clearly marked, and is sometimes very large. Frequently the external epicondylic line passing through this tubercle is extended as a long, narrow sharp-edged ridge.

The *tibia* (figs. 19, 20, and 21) is usually characterized by a very prominent cnemial crest which fades out inferiorly in the lower portion of the upper third of this element.   No peculiar characters are noted in the *fibula*.

The *astragalus* has much the same form as in *Canis pambasileus*, excepting in the vertical diameter of the neck.   The distal face for articulation with the navicular is transversely elongated in *C. dirus* to such an extent that the long diameter is about one-third greater than the short or vertical diameter.   In *C. pambasileus* the neck and head are thicker, and the terminal face for articulation with the navicular is more nearly round.

In the *calcaneum* the distal face for articulation with the cuboid tends to be a little narrower transversely and more nearly quadrate in form in *C. pambasileus* than in *C. dirus*.   The *cuboid* is a little narrower transversely in proportion to its length, and the distal face for articulation with metatarsals four and five somewhat narrower in *C. dirus* than in *C. pambasileus*.   Corresponding to the form of the head of the astragalus the *navicular* is relatively narrow anteroposteriorly or vertically in *C. dirus*.   It is also noted that in this species the small posterior facet which meets the calcaneum is relatively larger than in *C. pambasileus*.   The cuneiform elements are not materially different from those of the modern wolves.

The *metatarsals*, like the metacarpals, are relatively somewhat shorter in the average specimen of *C. dirus* than in *C. pambasileus*, though large specimens are present which exceed the largest measurements known in the latter form.   The metatarsals of *C. dirus*, even where shorter absolutely than in *C. pambasileus*, are distinctly wider anteroposteriorly in the upper half of the shaft.   Metatarsal

I of *C. dirus* does not appear to show any noteworthy difference from that of the modern wolves. It is at least as large relatively as in *C. pambasileus*. Metatarsal II (fig. 23) is slightly narrower transversely at the proximal articular end than in *C. pambasileus*, and the angle on the median side of the shaft is less distinctly marked than in that form. Metatarsal IV, in addition to the greater anteroposterior width of the shaft, shows a sharper antero-median angle in the middle third of the shaft. Metatarsal V (fig. 22) is very distinctly wider anteroposteriorly in *C. dirus* than in *C. pambasileus* and *C. occidentalis*. It is further characterized by the great prominence of the tuberosity external to the proximal

22   23
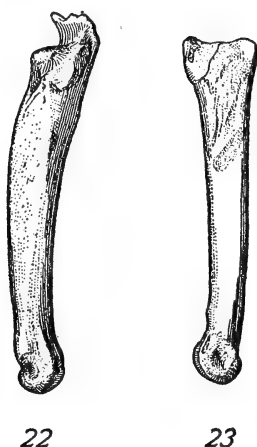
FIGS. 22 AND 23. *Canis dirus* Leidy. Metatarsals, no. 19475, × ½. Fig. 22, right metatarsal five, medial aspect; fig. 23, right metatarsal two, lateral aspect. Rancho La Brea Beds.

articular facet; in this character it is, however, not distinctly different from *C. occidentalis*.

As nearly as can be determined, relatively small size of the proximal phalanges obtains in the hind feet, as in the anterior extremities.

MEASUREMENTS OF IMPORTANT SKELETAL PARTS

The following measurements are taken from skeletal elements representing individuals of relatively large size. It is not certain that any two of the elements chosen represent the same individual.

Atlas, greatest transverse diameter... 120.5 mm.
Axis, greatest anteroposterior diameter of neural spine......................   73.7
Scapula, greatest height... 201

Plevis, greatest length... 228 mm.
Humerus, greatest length.. 240
Radius, greatest length.. 220
Metacarpal four, greatest length... 90.5
Femur, greatest length.. 260
Tibia, greatest length... 237
Metatarsal four, greatest length... 102.3

Comparison of Rancho La Brea Specimens with Previously Known Material

Comparison with the Type Specimen.—In order to fix the systematic position of the California species satisfactorily it was considered of the utmost importance to make a comparison with Leidy's type specimen. Mr. Witmer Stone of the Philadelphia Academy of Natural Sciences responded most cordially to a request for the loan of the original specimen, making it possible to compare the California collection with the type.

As a result of the comparison of the type with a large number of the specimens from the asphalt deposits, there appears to be no essential difference between the Indiana and the California forms. Such differences as exist are hardly greater than the minor individual differences among California specimens evidently representing one species.

In the type specimen (pl. 25, fig. 3) the form of M^1, the most important tooth of the upper dentition, differs from that of the other wolves and resembles the California specimens in the extreme reduction of the hypocone. The form of this tooth is in general similar in the Indiana and California forms. If any difference is noticeable, it is in the slightly wider bases of the paracone and the metacone, and in the distinctly concave posterior border of the average California specimen. Numerous individuals are present in the California collection in which the outer pair of tubercles does not show a broader base than in Leidy's type. The posterior border of most of the California specimens is generally rather sharply concave immediately behind the depression for the reception of the hypoconid of M_1. In the type the posterior border is very slightly concave at this point. In the type specimen the enamel has been almost entirely broken away from the outer and posterior sides of the metacone; and as the extension of the cingulum around the postero-external angle of the tooth is largely re-

moved, the border appears unnaturally straight. In a few California specimens the posterior border is almost as straight with the postero-external portion of the cingulum present as it now appears in the type specimen with the enamel absent from this region.

In the type specimen the cingulum of the anterior side of the paracone of M^1 appears relatively weak owing to the breaking away of the enamel immediately above the lower border of the cingulum. Judging from its sharp inferior ridge, the cingulum in this region was fully as strongly developed originally as in the Rancho La Brea specimens.

In Leidy's description attention is called to the greater abruptness of the external portion of the basal ridge or cingulum than in the Recent wolves. In the type specimen the external portion of the cingulum of M^1 is marked by a fairly sharp ridge extending along the base of the paracone. This ridge is better developed than in most of the large modern wolves, and the inferior side of that portion of the cingulum bordering the posterior part of the base of the paracone forms a somewhat sharper ridge than in the average of the Rancho La Brea specimens. In some of the California specimens, however, the form and strength of the external cingulum correspond quite closely to what we see in the type.

The form of M^2 in the type does not differ materially from that in the California specimens. The anterior end of the hypocone is extended around the inner and anterior side of the protocone, whereas in many of the California specimens it is interrupted on the antero-internal region of the tooth. There are, however, a number of individuals from Rancho La Brea in which precisely the relations shown here are exhibited. In this tooth the metacone appears to approach the size of the paracone rather more closely than in most of the California specimens. The enamel being removed from both tubercles, it would be unsafe to accept the relative dimensions as certainly representing the true external form. Moreover, some of the Rancho La Brea specimens show practically the same relative dimensions of paracone and metacone as appear in M^2 of the type specimen.

The superior carnassial of the type is badly broken, and shows nothing of the protocone blade. The antero-internal root does not extend far in toward the median line, indicating a small deuterocone as in the California specimens.

The form of P² and P³ of the type is closely similar to that of the California specimens. The extraordinarily strong internal cingula and the strong antero-internal ridges which Leidy mentions as occurring on these teeth in the type are noticed also in most of the Rancho La Brea specimens.

The form of the maxillary bone of the type is not noticeably different from that in the California species, excepting that the superior border of the infraorbital foramen is situated a little lower than in the larger specimens from Rancho La Brea.

Comparison with Cope's Texas Specimen.—The material which Cope described from the Texas Pleistocene includes very little on which to base a comparison. Fortunately the first upper molar (pl. 25, fig. 5), which is the most characteristic tooth in the whole dental series of *C. dirus*, is represented. The dimensions of this tooth, as nearly as can be determined from Cope's figure of the specimen, are near to those of the type and to those of the California specimens. The general form of the tooth is clearly similar to that of both the type and the California material in the essential characters. The hypocone is greatly reduced, and the protocone is of moderate size, while the paracone and metacone are rather large. According to Cope's description and figure, the alveolus of the antero-internal root of the superior carnassial extends far forward so that its anterior border overlaps the posterior third of P³. Such a form in this root has not been exactly duplicated in the California material, although it is suggested in one specimen. If it is normal it would probably constitute a valid character distinguishing the Texas form. It is conceivable that the form of root seen here is abnormal. It seems quite unnecessary unless the deuterocone were very largely developed, and since the hypocone of M¹ is much reduced and the crushing power weak it is not probable that the deuterocone of P⁴ was unusually developed.

Cope noted that the Texas specimen differed from Leidy's type in the following particulars: P³ distinctly longer and the external cingulum weaker; internal root of P⁴ extended farther forward; protocone of M¹ less conic than in the type and external cingulum of M¹ weaker. He suggested that the difference in the external cingula might be due to age, and was inclined to consider the two individuals as representing the same species.

In Cope's figure of the Texas specimen[16] there is a suggestion of a break at the postero-external angle of M¹, which has carried away the cingulum at this point. If this is the case, the antero-posterior diameter of M¹ would be shortened, and the length of P³ would appear relatively large. The character of the external cingulum is found to be quite variable in the Rancho La Brea series of specimens. The nature of the antero-internal root of P⁴ has been referred to above by the writer. The slight difference in the degree of lateral compression of the protocone of M¹ is fully equalled among the individuals of the Rancho La Brea series.

So far as evidence is available, there seems to be good reason for considering the California and Texas forms as closely related, if not identical species.

Comparison with Material from Sheridan Formation.—A specimen in the collections of the American Museum which was obtained in the Sheridan formation of Kansas evidently represents *Canis dirus*. It consists of a lower jaw (no. 10391 Amer. Mus. Nat. Hist.) with well-worn dentition. Measurements of the mandible and dentition correspond closely with those of average specimens of *C. dirus* from Rancho La Brea, as is shown in the table of measurements on page 778. The mandible is exceptionally high and thick as in *C. dirus*. The massive sectorial is indistinguishable in form from that of *C. dirus*, as is also M₂. P₄ is noticeably large compared with the corresponding tooth in *C. occidentalis*, and in this respect resembles *C. dirus*. The Sheridan Beds are presumed to represent an early phase of the Pleistocene.

Comparison with Material from the Valley of Mexico.—Of considerable interest in connection with a study of the distribution of the American Pleistocene fauna is the occurrence in the Valley of Mexico of remains indistinguishable from the specimens of *Canis dirus* from Rancho La Brea.

The recent investigations of Freudenberg[17] have shown the existence in Mexico of a varied mammalian fauna, which resembles in many respects the Pleistocene fauna of the California region. Included in the assemblage are several specimens of a large wolf.

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[16] Cope, E. D., Jour. Acad. Sc. Philad., ser. 2, vol. 9, pl. 21, fig. 15, 1895.

[17] Freudenberg, W., Geol. u. Palae. Abh., N.F., Bd. 9, Heft 3, 1910. Die Säugethierfauna des Pliocäns und Postpliocäns von Mexico.

Photographs and a cast of the best preserved specimen[18] which Dr. Freudenberg very kindly placed at the writer's disposal represent an animal which does not appear to be specifically distinguishable from the Rancho La Brea form of *C. dirus*. No remains of the dentition of the Mexican type seem to have been obtained, so that a fully satisfactory determination of the characters is not possible, but the close relationship of the forms is evident from such comparisons as can be made. Especially noticeable are the similarity in size, in the form of the occipital region, and in the nature of the overhanging inion region (fig. 24). The last character seems to be practically diagnostic of the *C. dirus* group. In the large

Fig. 24. *Canis dirus* Leidy. Posterior portion of a cranium, × ½. Tequixquiac, Mexico. Adapted from Freudenberg.

number of specimens available in the collections from Rancho La Brea the individuals unquestionably included in the species referred to *C. dirus* show considerable range of size and form. The Mexican species falls well within the range of variation of the Rancho La Brea specimens. The marked angle in the forehead of the Mexican specimen, formed by the sharp downward slope of the fronto-maxillary region above the orbit, is matched by the contour of the skull in several specimens representing old individuals from Rancho La Brea.

Comparison with Previously Described Californian Material.—The specimens already described from California, comprising the man-

[18] See Freudenberg, *ibid.*, Taf. 6, figs. 2, 3, 4.

dible from Livermore Valley[19] and the fragment of a lower jaw from Tulare County[20], may both presumably be included within the limits of *Canis dirus*. The jaw from Livermore Valley (fig. 25), as shown by the table of measurements below, is closely similar in
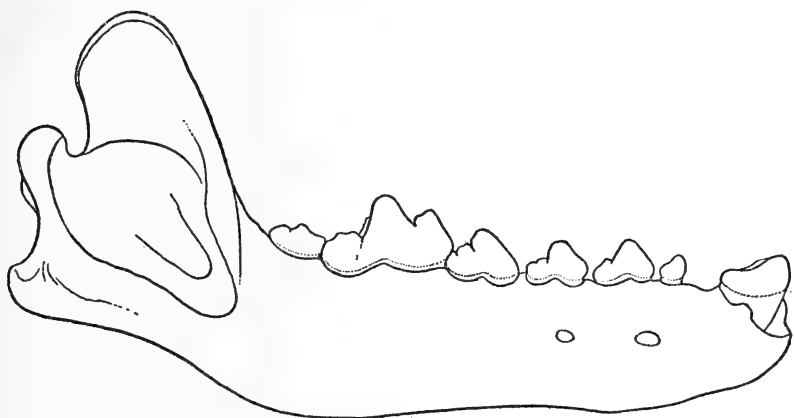
Fig. 25. *Canis dirus* Leidy. Right ramus of mandible, × ½. Livermore Valley, California. Adapted from Leidy.
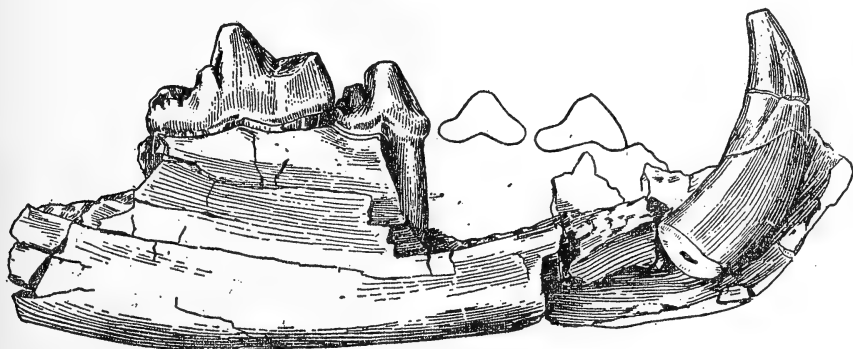
Fig. 26. *Canis dirus* Leidy. A portion of the left ramus of the mandible, × ⅔. Oil Springs, Oil Cañon, Tulare County, California.

dimensions to specimens from Rancho La Brea. The specimen from Tulare County (fig. 26) seemed to show a somewhat heavier jaw than the individuals from Rancho La Brea. This may have been due in part to crushing, as the specimen was much broken. The measurement of the canine is much smaller than that in the

[19] Leidy, J., Geol. Surv. Terrs., vol. i, Foss. Verts., p. 230, 1873.
[20] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, no. 14, p. 288, 1903.

larger individuals from Rancho La Brea, but was evidently taken somewhat higher up on the cone of the tooth. Considering the amount of variation known in the specimens at Rancho La Brea, there seems to be good reason for including both the Livermore Valley and Tulare County specimens in the group of *Canis dirus*.

COMPARATIVE MEASUREMENTS

	No. 10856, large specimen, Rancho La Brea	No. 10834, medium specimen, Rancho La Brea	Livermore Valley specimen	Tulare County specimen	Kansas specimen, Sheridan Beds
Length of lower jaw from condyle to anterior side of canine............	219 *ap*	204 mm.	200	..	198
Depth of lower jaw at condyle.......	48	44	44.1	..	43
Depth of lower jaw at M_1..........	39.7	37	37.5	42	39.5 *ap*
Length from posterior side of M_3 to anterior side of canine............	148	137.7	137.5	..	133 *ap*
Length of inferior molar and premolar series.........................	119.5	113	112.5	..	110 *ap*
Anteroposterior diameter of inferior canine.........................	17.5	16.5	17.5	13	...
M_1, anteroposterior diameter........	35.7	34.5	34.1	35	33.7

ap approximate.

A fragment of a large wolf jaw (no. 5018) obtained in the Pleistocene deposits of Potter Creek Cave, Shasta County, California,[21]

COMPARATIVE MEASUREMENTS

	No. 5018 Potter Creek Cave specimen	No. 10856 C. dirus Rancho La Brea	No. 10727 C. dirus Rancho La Brea	C. occidentalis, Recent (a)	C. pambasileus, Recent (b)
M_1, greatest anteroposterior diameter.....	*ap*33 mm.	35.7	32	32	29.7
M_1, transverse diameter of heel...........	9.5	13.5	11.4	..	10
P_4, greatest anteroposterior diameter......	15.3	20	19.8	16	16.5
P_4, greatest transverse diameter...........	7.3	10.5	9.3	8.5	7.7
P_3, greatest anteroposterior diameter......	13.2	16.7	15.8	..	14.6
P_2, greatest anteroposterior diameter......	12.3	15.4	15	..	12.5

ap approximate.
(a) No. 115995 U. S. Nat. Mus.
(b) No. 8321. Calif. Mus. Vert. Zool.

[21] Univ. Calif. Publ. Am. Arch. Ethn., vol. 2, no. 1, p. 17, 1904.

shows some of the characters of *Canis dirus*, as is indicated in the table of measurements above. The inferior carnassial is larger than that of the Recent wolves, but the heel is much narrower than in the typical *C. dirus*, and the inferior premolars are relatively very small. The only specimen known is so fragmentary that final judgment as to its affinities should probably be withheld until better material can be obtained, but there does not seem to be sufficient evidence available to warrant definite separation of the Potter Creek form from the group of *C. occidentalis*.

CANIS MILLERI, n. sp.
Text figures 27 to 31

Type specimen, a skull with lower jaw, no. 11257, University of California Collections in Vertebrate Palaeontology. Found four feet below the surface in the asphalt deposits at Rancho La Brea. The species is named in honor of Dr. L. H. Miller, whose assistance in furthering the investigations at Rancho La Brea has been greatly appreciated by the writer.

Skull and dentition (figs. 27, 28, 29, 30, and 31) intermediate between *Canis occidentalis* and *C. dirus*. Characters differing from those of *C. dirus* as follows: Skull much smaller. Nasals narrower posteriorly. Nasal processes of frontals broader and extending much farther forward. Fronto-facial region relatively flat, and postorbital processes of frontals small. Sagittal crest low. Overhang of inion relatively small. Sharp median ridge of occiput wanting. Posterior palatine foramina relatively far forward. Lower jaw slightly narrower anteriorly than in typical *C. dirus*. Teeth relatively large, P^4 and M_1 especially heavy. M^1 (fig. 31) with unusually large hypocone, which extends around the antero-internal region of the protocone, and is connected with a low shelf of the cingulum on the anterior side of the tooth. P_2 with a distinct posterior cusp. M_1 relatively large.

The skull of *Canis milleri* differs markedly from that of *C. occidentalis* in its greater width, especially in the palate, and in the much more massive dentition. P^4 and M^1 are much larger in proportion to the size of the skull than in any of the true timber wolves. P^4 greatly exceeds the relative dimensions in typical *C. occidentalis*. In the general form and massiveness of P^4, this

species closely approaches *C. dirus*, from which it is, however,
clearly separated by other characters as indicated above. The
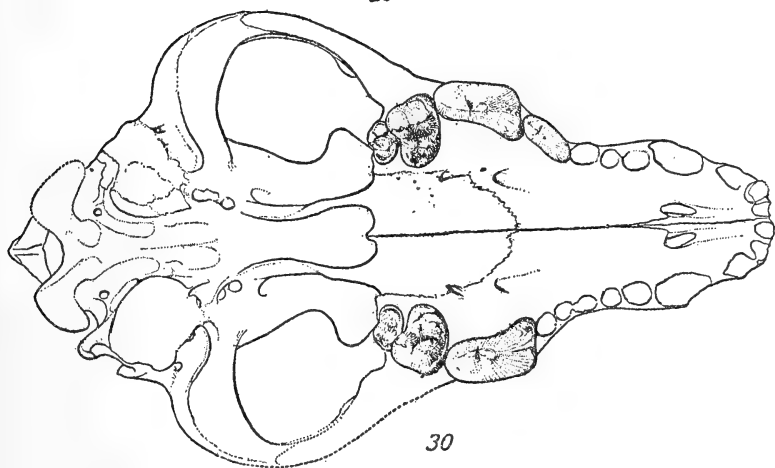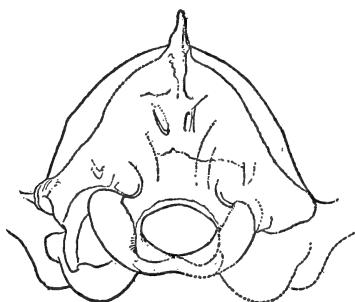nearest approach to the assemblage of characters seen in *C. milleri*
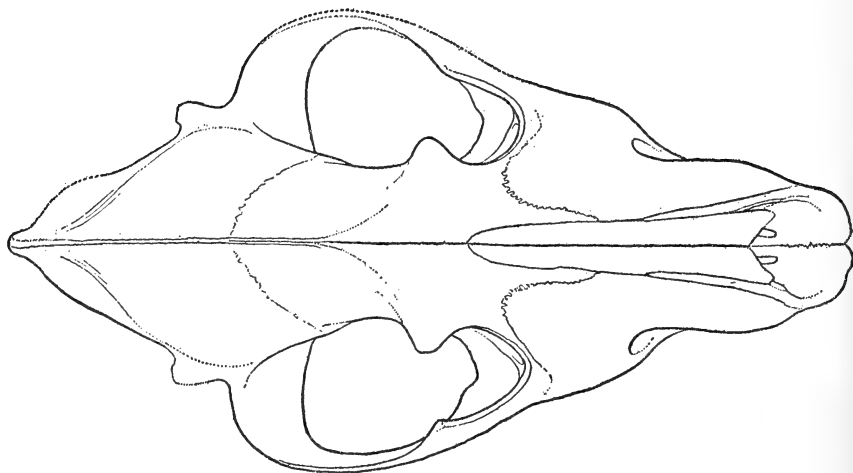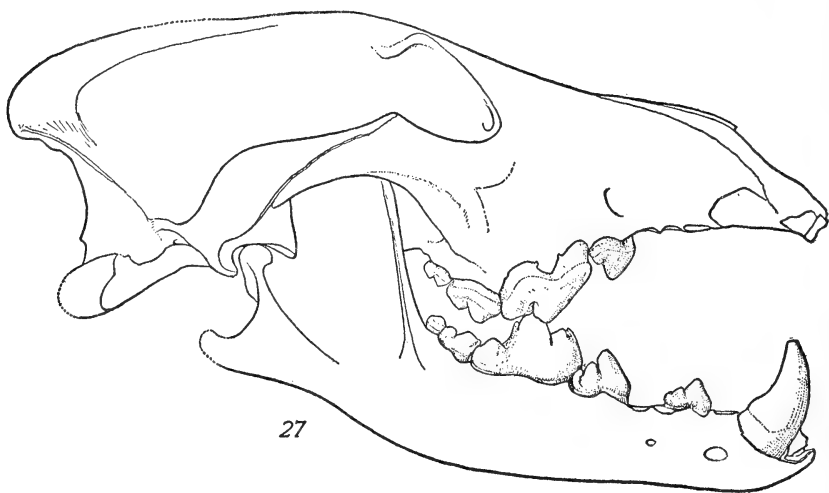
Figs. 27 and 28. *Canis milleri* Merriam, J. C. Skull, no. 11257, × ⅔. Fig. 27, lateral view; fig. 28, superior view. Rancho La Brea Beds.

is found in *C. occidentalis furlongi*. From this form *C. milleri* is
distinguished by greater width of skull, especially in the palatine
region; greater interorbital width of the frontal region; shorter and

wider nasals; longer nasal processes of the frontals; somewhat heavier upper carnassials; and wider inner lobes of the upper molars.

The form seen in skull no. 11257 was at first considered as probably representing a young female of *Canis dirus*, the peculiar assemblage of characters observed being in part such as might occur in young individuals of this sex. Careful analysis of the collection does not, however, support this view. A study of between forty

29

30

and fifty skulls of *C. dirus* shows no other specimen exhibiting the characters seen here, though there are available well-preserved specimens representing all stages of development, from forms with milk dentition to very aged individuals with teeth nearly worn away. In the collection of specimens unquestionably referred to *C. dirus* there is much variation in many of the characters, particularly in size, and there is reason to believe that among the

adults a number of the lighter skulls with weaker muscle attachments represent females. It is, to say the least, highly improbable that skull no. 11257 represents the only female in this collection. That the characters of youth added to those of sex are competent to extend the range of form in *C. dirus* so far as to reach the assemblage of characters seen in specimen no. 11257 seems also improbable. This skull is that of a young adult much beyond the stage of development of many *C. dirus* specimens in which the typical characters of the species are strongly expressed. Moreover, the variation in form of the nasals and nasal processes of the frontals is just opposite to that which would be expected in youthful animals. In all young specimens the nasal processes of the frontals are exceptionally short, while in no. 11257 they are larger than in any other individuals, including those of advanced age.
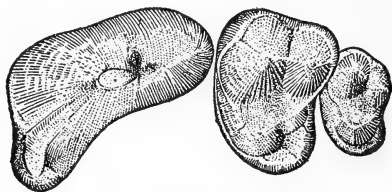
Fig. 31. *Canis milleri* Merriam, J. C. Superior carnassial and superior molars, occlusal view, no. 11257, natural size. Rancho La Brea Beds.

The Miller wolf was an animal about as large as the modern timber wolf, but with a relatively shorter and heavier head. It is to be presumed that the living animal differed very noticeably from the dire wolf in size and in general contour of the body. Of the Miller wolf as yet we know with certainty only the skull. The species was evidently a relatively rare form at Rancho La Brea, but may have been much more common in other regions at the time this deposit was forming.

For measurements of *Canis milleri* see table of comparative measurements of skull, p. 771, and dentition, p. 778.

CANIS OCCIDENTALIS FURLONGI Merriam, J. C.

Text figures 32a to 33b

Canis occidentalis furlongi Merriam, J. C. Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 393, 1910.

There are in the collections from Rancho La Brea several fragmentary specimens representing a wolf species near *Canis occiden-*

talis. One of these specimens was made the type of a new sub-
species in the publication cited above. The type material of the
Rancho La Brea form when compared with typical *C. occidentalis*
exhibits a tendency to relative narrowness of the nose, the superior
carnassial tends to be relatively massive, and the second upper
molar seems relatively narrow anteroposteriorly.

The Rancho La Brea specimens originally referred to *C. occi-
dentalis furlongi* differ from *C. dirus* particularly in the form of M¹
(figs. 32*a* and 32*b*). This tooth is relatively wide transversely, the
inner lobe is relatively narrow anteroposteriorly, and the hypo-
cone is relatively large. The hypocone has approximately the size

32*a*   32*b*

32*c*
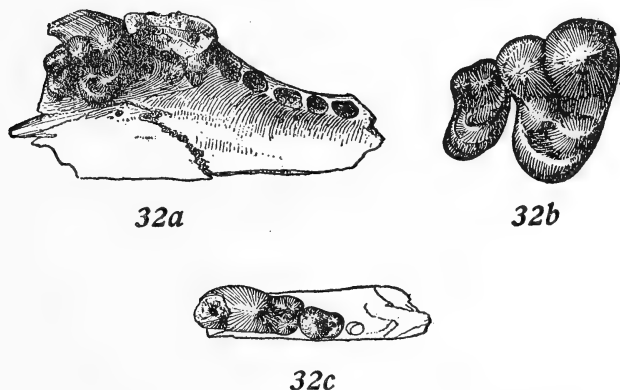
Figs. 32*a* to 32*c*. *Canis occidentalis furlongi* Merriam, J. C. No. 11283. Fig. 32*a*, por-
tion of the skull with dentition, inferior aspect, × ½; fig. 32*b*, M¹ and M², occlusal view,
natural size; fig. 32*c*, portion of lower jaw with molars, × ½. Rancho La Brea Beds.

and form seen in average specimens of wolves in the *C. occidentalis*
group, and as in that species the anterior end of the hypocone
ridge swings forward around the anterior side of the protocone
instead of being interrupted as in *C. dirus.*

In a fragment of a mandible (fig. 32*c*) accompanying the upper
jaw specimen most clearly resembling *C. occidentalis*, the carnassial
shows a metaconid even weaker than that of *C. dirus*, while the
entoconid is slightly larger than in average *C. dirus* specimens.
On M₂ the protoconid seems slightly smaller and the heel region
relatively larger than in *C. dirus*, though the metaconid is small
compared with the protoconid. The proportions of the talonid
region with reference to the trigonid are much as in *C. occidentalis*.

In one of the small specimens (no. 10733) of the *C. occidentalis* type from Rancho La Brea the hypocone of M^1 is rather small, though larger than in the typical *C. dirus*, and the anterior extension of the hypocone ridge around the anterior side of the protocone is barely interrupted. M^2 is in this specimen of the narrow form with small metacone and hypocone. P^3 differs from the corresponding tooth of *C. dirus* in being very narrow instead of wide posteriorly, and in the almost entire absence of a posterior basal tubercle behind the posterior cusp. The portion of the palatine region present seems to narrow anteriorly. This specimen varies in some respects toward *C. dirus*, but the size, general form, and especially the proportions of M^1 indicate that it belongs with the group of individuals referred to *C. occidentalis furlongi* rather than to *C. dirus* or to *C. milleri*.

A small wolf skull, no. 19792, of the *C. occidentalis* type, obtained at Rancho La Brea by Dr. L. H. Miller, resembles *C. occidentalis furlongi* in the characters of the upper molars, and is referred to that form. This specimen (figs. 33*a* and 33*b*) differs widely from *C. dirus*, and in most characters in which it differs from *C. dirus*, it resembles *C. occidentalis*. The skull is much smaller than in *C. dirus*, and is also relatively narrower. The nasal bones are long and narrow. The postorbital processes of the frontals are small, the sagittal crest is low, and the inion does not show the extraordinary overhang so characteristic of *C. dirus*. The posterior narial opening is narrow at the anterior end, instead of flaring as is commonly seen in *C. dirus*. The posterior palatine foramina are situated relatively far forward as in *C. occidentalis*. The molars are of the *C. occidentalis* form. P^4 is, however, much heavier than in the modern wolves and resembles closely P^4 of *C. milleri*. In the northern wolves of the *C. pambasileus* type the upper carnassial may be quite massive, but falls considerably below the stage of development seen in this form.

Although there is a noticeable variation in the size of the teeth in the Rancho La Brea specimens referred to *C. occidentalis furlongi*, this material seems to represent a single form which differs from the modern gray wolves at least to the extent of subspecific variation.

This wolf type was evidently relatively rare compared with *C.*

dirus, and was much less common than the coyotes in this particular region. From what is known of the distribution of wolves of the *C. occidentalis* type it is doubtful whether they have ever been relatively abundant in the region of southwestern United States,
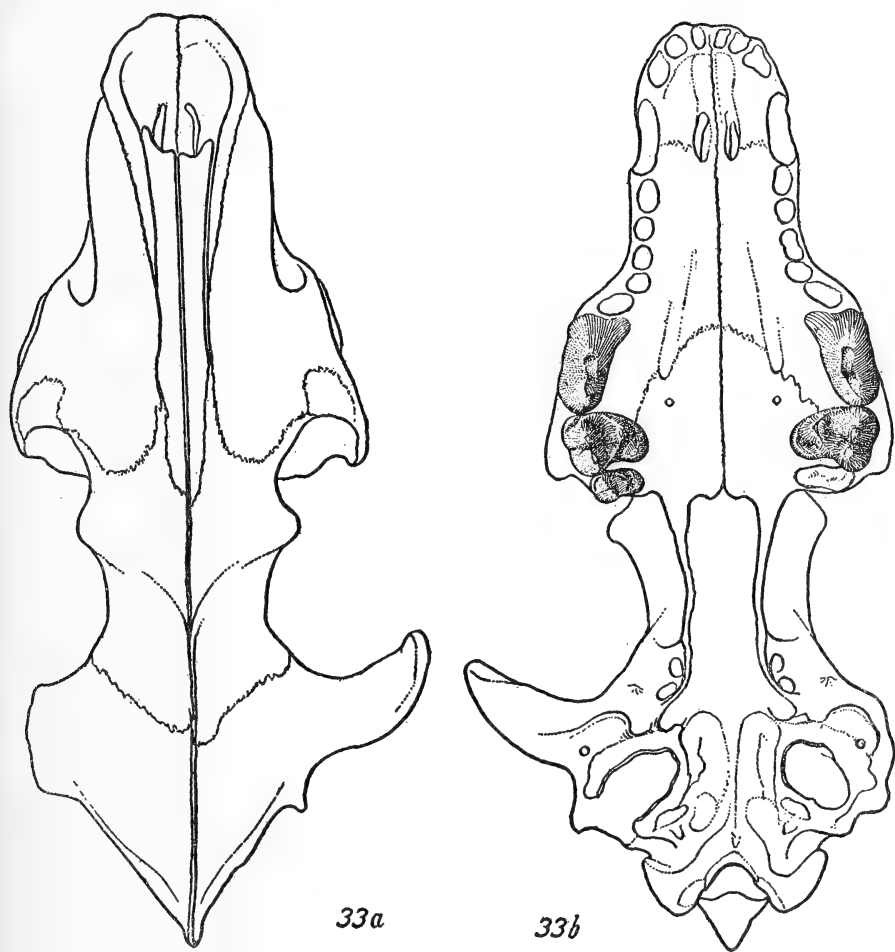
FIGS. 33*a* AND 33*b*. *Canis occidentalis furlongi* Merriam, J. C. No. 19792, × ½. Fig. 33*a*, skull superior view; fig. 33*b*, skull inferior view. Rancho La Brea Beds.

as *C. dirus* was certainly the dominant species through a considerable part of Pleistocene time, and the coyote group has apparently been the most abundantly represented canid type since the disappearance of *C. dirus*.

MEASUREMENTS OF DENTITION AND SKULL

	No. 11283 Rancho La Brea	No. 19792 Rancho La Brea	No. 10733 Rancho La Brea	C. dirus (a) Rancho La Brea	C. milleri (b) Rancho La Brea	C. occidentalis (c) Recent
Length, posterior side of superior canine to posterior side of M².......	81.5 mm.	87	...	115.5	86	91
Length, anterior side of P⁴ to posterior side M².........................	44.7	48.5	...	54	47.7	46
P⁴, anteroposterior diameter.........	23.6	26.8	24	30.7	28.2	25.5
M¹, anteroposterior diameter along outer border.....................	16	17.2	15.5	18.8	17	17.4
M¹, greatest transverse diameter....	19.3	21.5	18	23	20.7	19.4
M², anteroposterior diameter along outer border.....................	8	7.9	8.2	9.2	9	8.5
M², greatest transverse diameter....	10.8	13.5	10.5	14.4	12.9	12.3
Width, from outer side of alveolus of M¹ to median line...............	39	39.6	37.7	46.5	41.8	38.3
Width, from outer side of alveolus of P¹ to median line.................	18	20.2	...	27.5	22.5	19.5
M₁, anteroposterior diameter........	27	...	...	34.5	32	28.3
M₁, thickness measured across protoconid..........................	11.5	...	...	13.6	13.5	11
M₂, anteroposterior diameter........	11.5	...	...	13.3	12.4	11.7

(a) No. 10834
(b) No. 11257
(c) No. 1308. U. S. Nat. Mus.

CANIS OCHROPUS ORCUTTI Merriam, J. C.

Text figures 34 to 40

Canis orcutti Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 391, 1910.

Type specimen, no. 10842, University of California Collections in Vertebrate Palaeontology. From the asphalt beds of Rancho La Brea, California.

The specimens referred to this form are next in number to those representing *Canis dirus* in the beds at Rancho La Brea, but are relatively rare compared with remains of that species. Though several factors may have tended to keep the number of coyotes entangled in the asphalt down to a percentage of the whole population somewhat less than in the case of the great wolves, it is probable that the smallness of the number of coyotes recovered is due mainly to an absolutely much smaller representation of these

forms in this region during the time of accumulation of the asphalt beds.

It is hardly to be presumed that coyotes would avoid the flat land bordering the hills to such an extent as to reduce the percentage of individuals entangled much below that in the case of *C. dirus*, though this might be true of the timber wolves. The principal factors which may have contributed to keep down the percentage of coyotes captured by the asphalt seem to be, nature of the lure attracting wolves, mode of hunting, and possible difference in intelligent recognition of the danger encountered. Most of the carnivores engulfed in the tar have been captured in one of three ways: by accidental crossing of soft tar pools, by the lure of water pools in association with tar springs, and by the lure of entangled animals which might serve as food. Accidents under the first two heads would occur with about the same frequency in the two groups of wolves unless in one of them a grade of intelligence was developed which enabled the individuals to obtain a relatively better knowledge of danger signs. Whether the coyote was the more intelligent animal is not easily determined. It did, however, possess a relatively larger, though absolutely smaller, brain. It is not improbable that its sight, hearing, and smell were more acute than in the great wolf. If this be true, there is reason to suspect that the coyote would more readily perceive and avoid a danger not unusual in this region.

The third factor, lure of animals, is the only one of the three which seems to have significance worth more than passing mention in this connection. Judging from such evidence as we have, it seems probable that the great wolves were powerful enough to prey upon animals of considerable size, that they were so constructed as to make the tearing apart of large animals fairly easy work, and that they were numerous enough to make hunting in packs a natural method of attack. The coyotes evidently preyed upon small mammals and birds, and hunted alone or in small groups. In all of the asphalt collections brought together thus far the number of individuals representing the larger mammals has been unexpectedly great compared with that of the smaller forms, and the number of birds which would naturally serve as food for coyotes is also small. It may therefore be true that the lure for large wolves was exceptionally good. It is to be noted, however, that even compared

with a small number of individuals representing the smaller mammals the number of coyotes is small. It seems therefore possible to explain the number of coyotes present either on the supposition that, owing to much superior intelligence, out of a large number relatively few succumbed to accidental encountering of the tar, or to the attraction of living bait, or on the theory that the number of
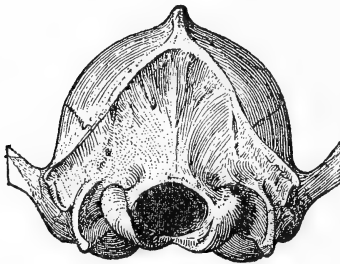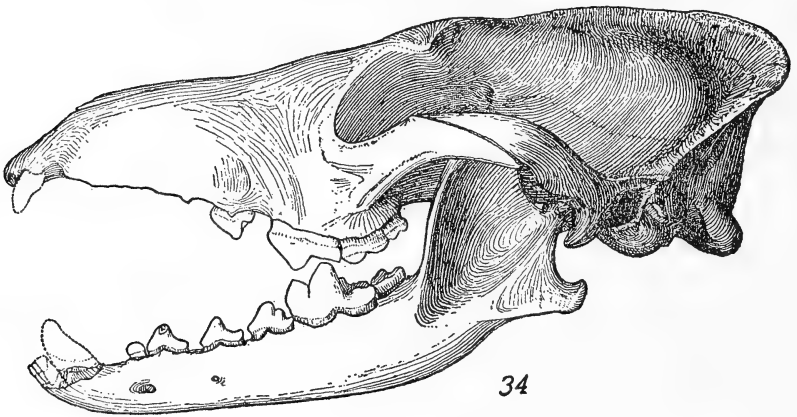
FIGS. 34 AND 35. *Canis ochropus orcutti* Merriam, J. C. Skull, no. 10842, × ½. Fig. 34, lateral view; fig. 35, posterior view. Rancho La Brea Beds.

coyotes in the region was absolutely very much smaller than that of the great wolves. The latter view seems to give the principal reason for the small representation.

This subspecies is closely related to *Canis ochropus* now living in southern California. The skulls of *Canis ochropus orcutti* average somewhat larger than in the living *C. ochropus*, and are noticeably broader across the palate and zygomatic arches (figs. 34, 35, and 40).

The mandible is considerably higher, particularly below the molars, and is also thicker transversely than in the living form of this region. The dimensions of the teeth do not vary greatly from the living species excepting in the thickness of both the upper and lower carnassials, which are heavier in the fossil form (figs. 36a and 36b). M^1 tends also to be somewhat heavier than in the typical *C. ochropus*, and in this respect more nearly approaches the typical *C.*

36a

36b

FIGS. 36a AND 36b. *Canis ochropus orcutti* Merriam, J. C. Fig. 36a, superior carnassial and molars, occlusal view, no. 19791, natural size; fig. 36b, inferior cheek-tooth dentition, occlusal view, no. 10842, × ½. Rancho La Brea Beds.
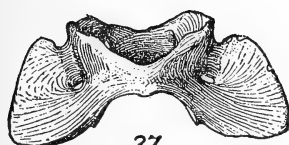
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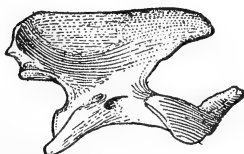
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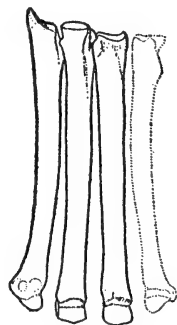
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FIG. 37. *Canis ochropus orcutti* Merriam, J. C. Inferior view of atlas, no. 10842, × ½. Rancho La Brea Beds.

FIG. 38. *Canis ochropus orcutti* Merriam, J. C. Lateral view of axis, no. 10842, × ½. Rancho La Brea Beds.

FIG. 39. *Canis ochropus orcutti* Merriam, J. C. Metatarsus, × ½. Rancho La Brea Beds.

latrans. In M_1 the metaconid seems to be slightly less prominent medially than in the typical *C. ochropus*, possibly owing to the greater thickness of the trigonid blade in the fossil form.

The form from Rancho La Brea differs from the typical *C. latrans* and resembles the type of *C. ochropus* in the relatively narrow anteroposterior diameter of M^1. M^2 is sometimes smaller than in either the typical *latrans* or the typical *ochropus* form.

A skeleton of this species which has been assembled from parts of separate individuals shows little difference from that of the living *C. ochropus* of this region. It is evident that the coyote of Rancho La Brea was a slender-legged creature, and was swift-footed like its living relative.

In the collection of canid forms from Rancho La Brea there are a number of fragmentary specimens representing parts of the cranium of small coyotes which are hardly to be distinguished from the corresponding regions in the skull of typical *C. ochropus*. It is not impossible that two forms, typical *C. ochropus* and *C. ochropus orcutti*, were present. It is also possible that all of the forms of Rancho La Brea should be included in one variety which should go under the name of the living *ochropus*. From such material as is available the writer is, however, inclined to believe that the Rancho La Brea form differs somewhat from the living type; and if all of the individuals are to be included in one subspecies, the use of the name *C. ochropus orcutti* for the group more truthfully represents the facts than would designation as typical *C. ochropus*. With a much larger series of specimens available it is possible that a further separation of the coyotes would be possible.

MEASUREMENTS OF SKULL AND DENTITION

	C. o. orcutti (a) large specimen Rancho La Brea	C. o. orcutti (b) small specimen Rancho La Brea	C. ochropus (c) large Recent specimen	C. latrans (d) Recent	C. andersoni (e) type specimen Rancho La Brea
Length from anterior end of premaxillaries to posterior side of occipital condyles........................	197.5 mm.	188.5	192	179.5	166.1
Width across zygomatic arches.......	....	108	104	106.8	91
Width between outer sides of tritocones of P^4.......................	....	65	57	58.9	56
Least width between superior borders of orbits.........................	....	38	35.4	29.6	31.9
Width between postorbital processes of frontals........................	....	55	53.5	44	38.2
Length, posterior side of superior canine to posterior side of M^2........	....	80.5	80	72.6	64.5*ap*
Length, anterior side of P^4 to posterior side of M^2......................	....	37.3	38.7	38.7	36.5*ap*
P^3, anteroposterior diameter..........	....	13.3	13.2	13.2	...
P^4, anteroposterior diameter..........	....	21.2	20.8	21	20
P^4, thickness across protocone........	....	8.5	7.5	7.7	7.8

MEASUREMENTS OF SKULL AND DENTITION—*Continued*

	C. o. orcutti (a) large specimen Rancho La Brea	C. o. orcutti (b) small specimen Rancho La Brea	C. ochropus (c) large Recent specimen	C. latrans (d) Recent	C. andersoni (e) type specimen Rancho La Brea
M^1, anteroposterior diameter measured along outer border...............	....	13.3 mm.	12.8	14	...
M^1, greatest transverse diameter......	....	16	16	16.2	...
M^2, anteroposterior diameter measured along outer border...............	....	7.3	8	7.5	...
M^2, greatest transverse diameter......	....	10.5	11.3	11.5	...

	No. 11278	C. ochropus (c)	C. latrans (d)
Length, anterior end of left ramus of mandible to middle of posterior side of condyles..........	145.5	149	140
Height of mandible below posterior side of P_2...	17	16.3	17.4
Height of mandible below posterior side of M_1...	22.5	19.4	20.9
Thickness of mandible below protoconid of M_1...	11.8	10	9.6
Length, posterior side inferior canine to posterior side of M_2.................................	85	85	77.5
P_3, anteroposterior diameter...................	11.7	11.5	12.5
P_3, greatest transverse diameter...............	4.8	4.5	4.8
M_1, anteroposterior diameter..................	22.9	22.2	22.5
M_1, greatest transverse diameter of trigonid.....	9.5	8.1	8.3
M_2, anteroposterior diameter.................	9.8	9.8	9.8

(a) No. 12264.
(b) No. 10842.
(c) No. 651, Univ. Calif. Mus. Vert. Zool.
(d) No. 10993.
(e) No. 12249.
ap approximate.

CANIS ANDERSONI Merriam, J. C.

Text figures 41 and 42

Canis andersoni Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 393, 1910.

Type specimen no. 12249, University of California Collections in Vertebrate Palaeontology. From the asphalt beds of Rancho La Brea, California.

A single specimen in the collections from Rancho La Brea represents a short-headed, coyote-like wolf quite different from any form known to the writer. The skull (figs. 41 and 42) is about as broad as that of *Canis ochropus* but is relatively very short, with a relatively short and broad muzzle. This difference is noticeable also in comparison with the typical *C. latrans*. Though this speci-

men represents a young individual, the permanent dentition had been complete and there is no reason to believe that the form and proportions of the skull would have changed materially in later life. Of the dentition only the superior carnassials have been preserved. These teeth have approximately the size of those in *C. ochropus*, but appear slightly thicker. A number of minor differences between this specimen and typical representatives of the known coyotes may have specific or subspecific value, but their estimation is not possible with any degree of satisfaction when only one specimen is available for comparison.
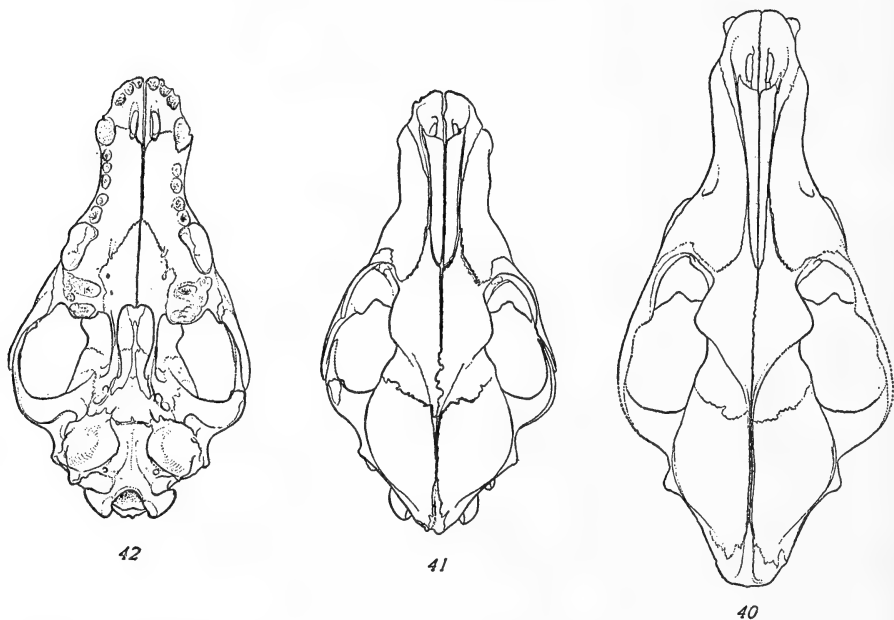
Fig. 40. *Canis ochropus orcutti* Merriam, J. C. Superior view of skull, no. 12264, $\times \frac{1}{3}$. Rancho La Brea Beds.

Figs. 41 and 42. *Canis andersoni* Merriam, J. C. Skull, no. 12249, $\times \frac{1}{3}$. Fig. 41, superior view; fig. 42, inferior view. Rancho La Brea Beds.

It is to be hoped that other material representing this form may be obtained so that some conception of the outlines of the body may be possible.

MEASUREMENTS OF SKULL AND DENTITION

	No. 12249
Length from anterior end of premaxillaries to posterior side of occipital condyles	166.1 mm.
Width across zygomatic arches	91
Width between outer sides of tritocones of P^4	56
Least width between superior borders of orbits	31.9
Width between postorbital processes of frontals	38.2
Length, posterior side of superior canine to posterior side of M^2	64.5*ap*

	No. 12249
Length, anterior side of P⁴ to posterior side of M²........................	36.5ap mm.
P⁴, anteroposterior diameter...	20
P⁴, thickness across protocone...	7.8

ap approximate.

UROCYON CALIFORNICUS Mearns

Text figure 43

A finely preserved skull (fig. 43), no. 12263, represents a form almost identical with the existing *Urocyon californicus* of southern California. As is indicated in the table of measurements below, the dimensions are very close to those of two Recent specimens from the San Jacinto region not far distant. It is interesting to note that this form has survived to the present day with less modification than the other canid types.
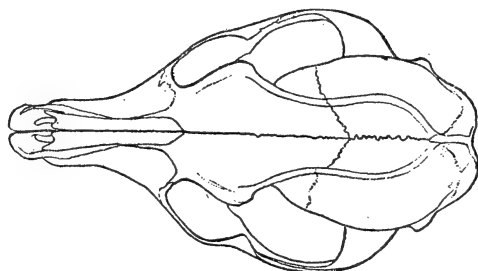
FIG. 43. *Urocyon californicus* Mearns. Superior view of skull, no. 12263, × ½. Rancho La Brea Beds.

Portions of the lower jaw and dentition of a form evidently representing this species are also known from Rancho La Brea.

MEASUREMENTS OF SKULL AND DENTITION

|	No. 12263 Rancho La Brea	No. 2324a Recent	No. 2316a Recent
Length of skull, anterior end of premaxillaries to posterior side occipital condyles................................	119.3 mm.	118.7	122.8
Width across zygomatic arches.........................	68.2	64.4	67.6
Least width between superior borders of orbits..........	23.8	22.5	26
Width of palate between inner borders of second upper molars..	17	15.8	18.4
Length of superior dental series from anterior side of canine alveolus to posterior side of M²......................	52.2	52.5	53.2
Length from anterior side of P⁴ to posterior side of M²....	22.3	22.5	22.3
P⁴, anteroposterior diameter along outer border..........	9.9	10	...
M¹, anteroposterior diameter along outer border.........	7.5	8.4	7.7
M¹, greatest transverse diameter.......................	10.6	11.4	10.5
M², anteroposterior diameter along outer border.........	5.4	6	5.6
M², greatest transverse diameter.......................	7.9	8.2	7.4

a Univ. Calif. Mus. Vert. Zool.
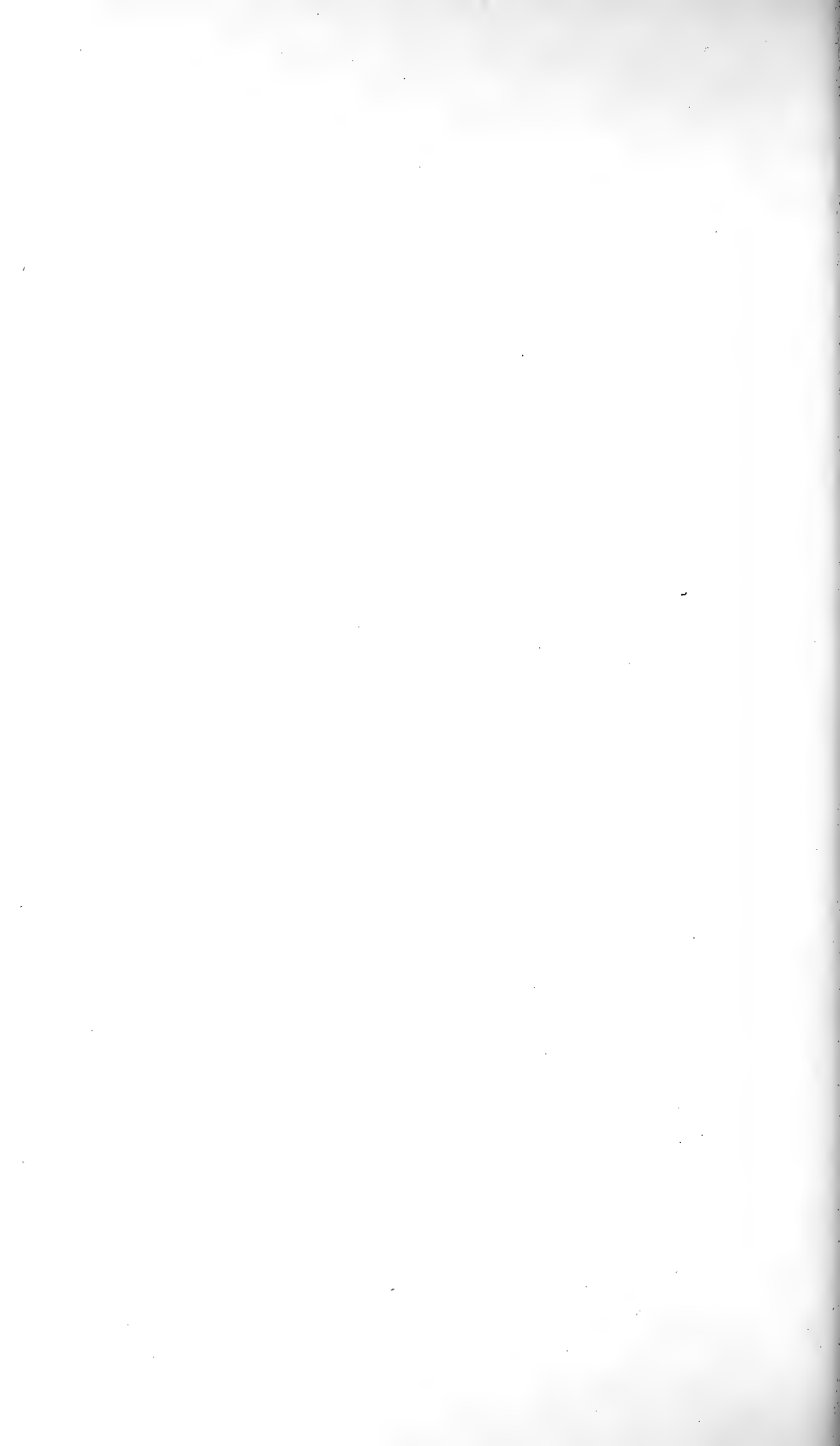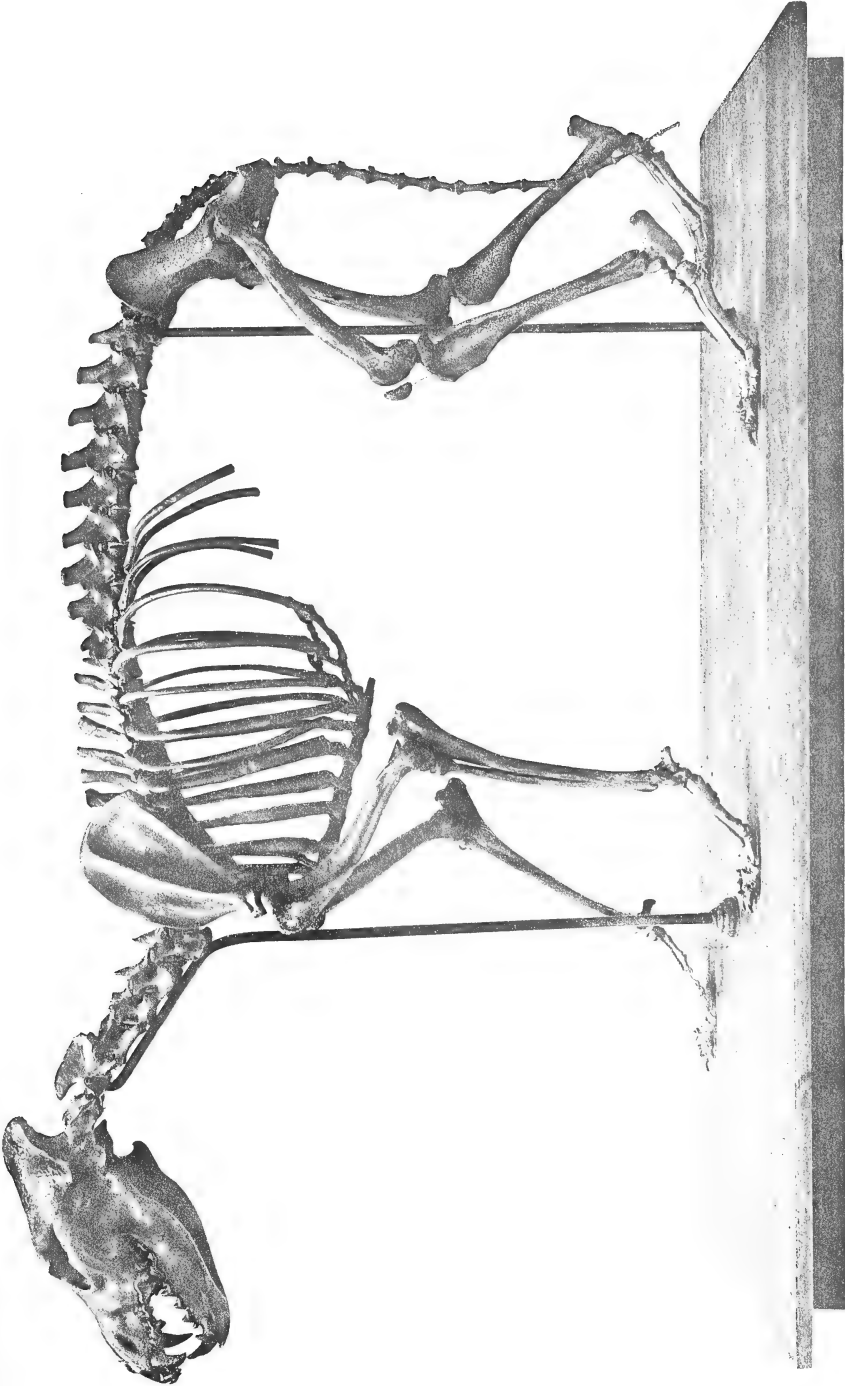
Canis dirus Leidy. Skeleton approximately one-seventh natural size. Rancho La Brea Beds
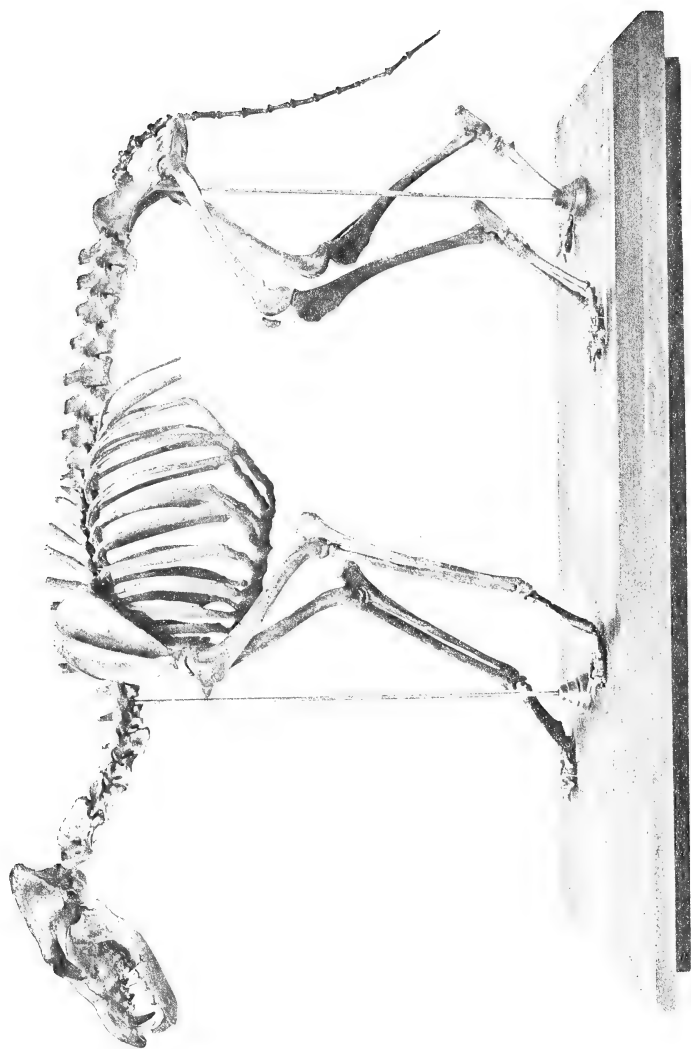
Canis ochropus orcutti Merriam, J. C. Skeleton approximately one-seventh natural size. Rancho La Brea Beds
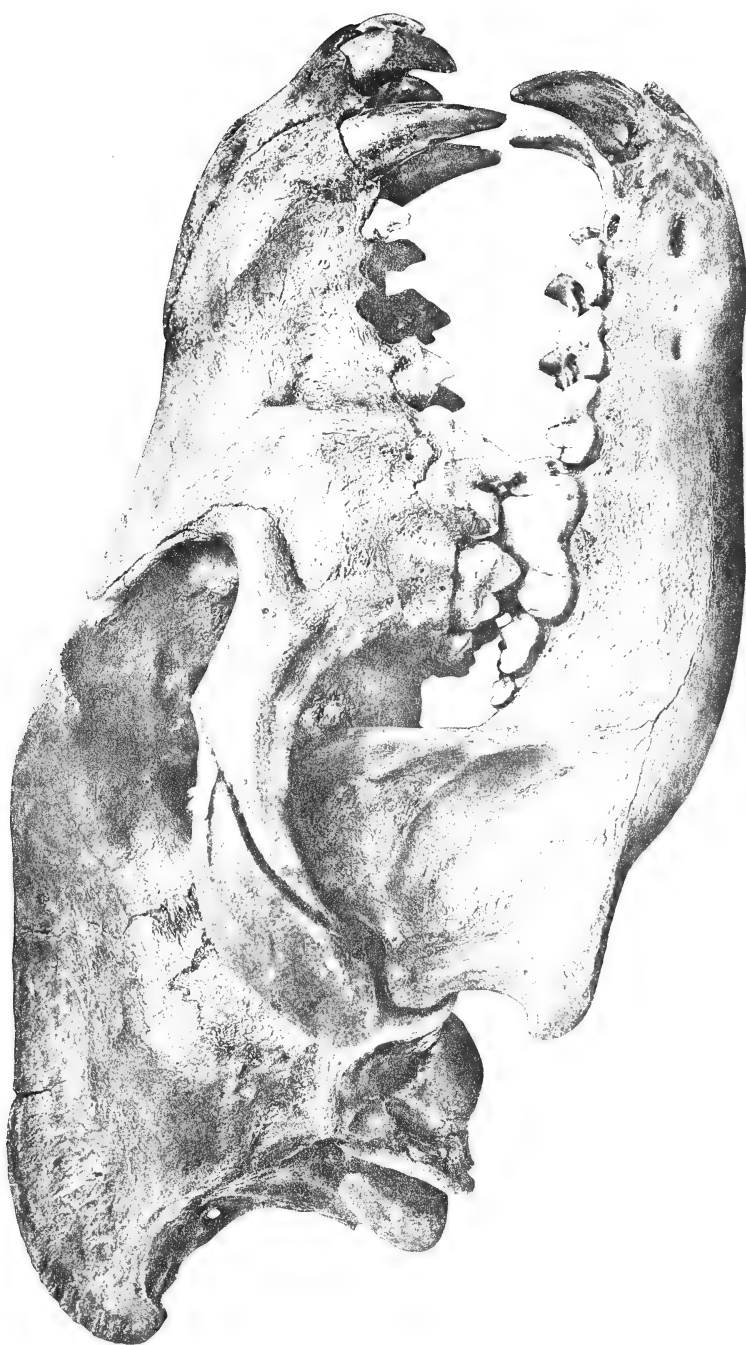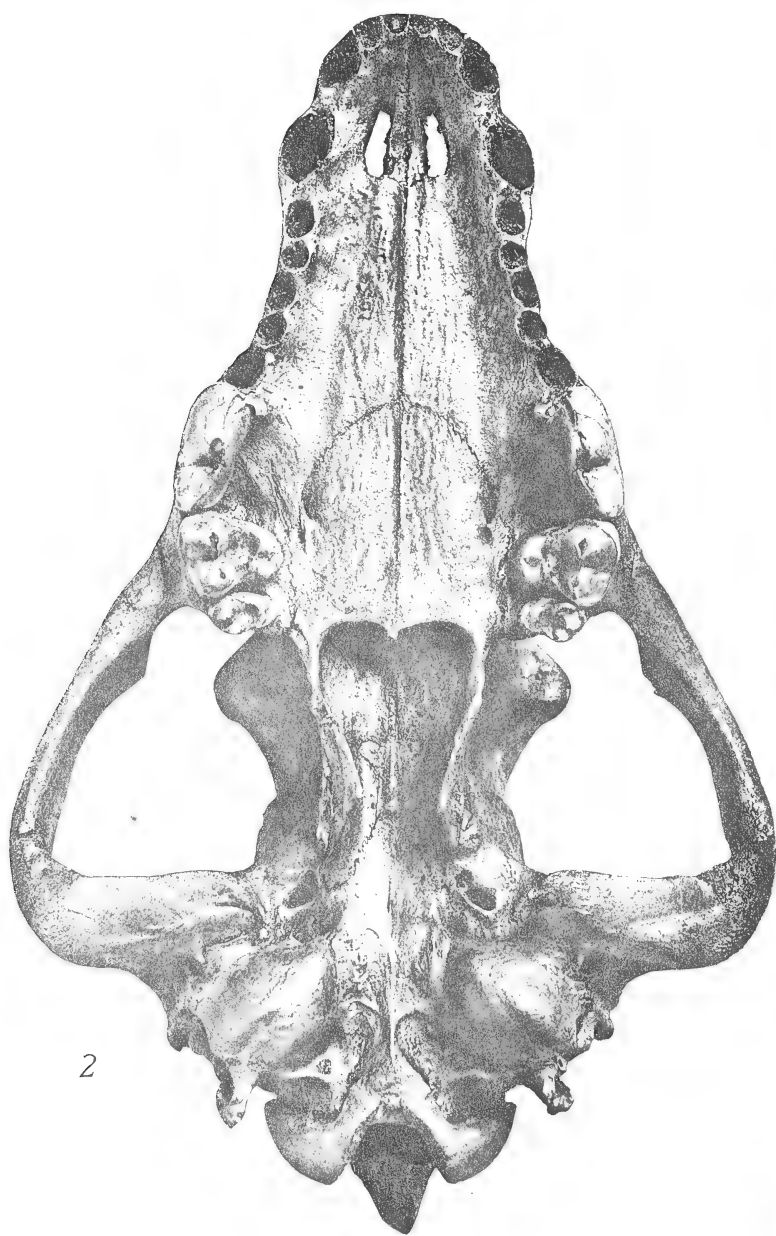
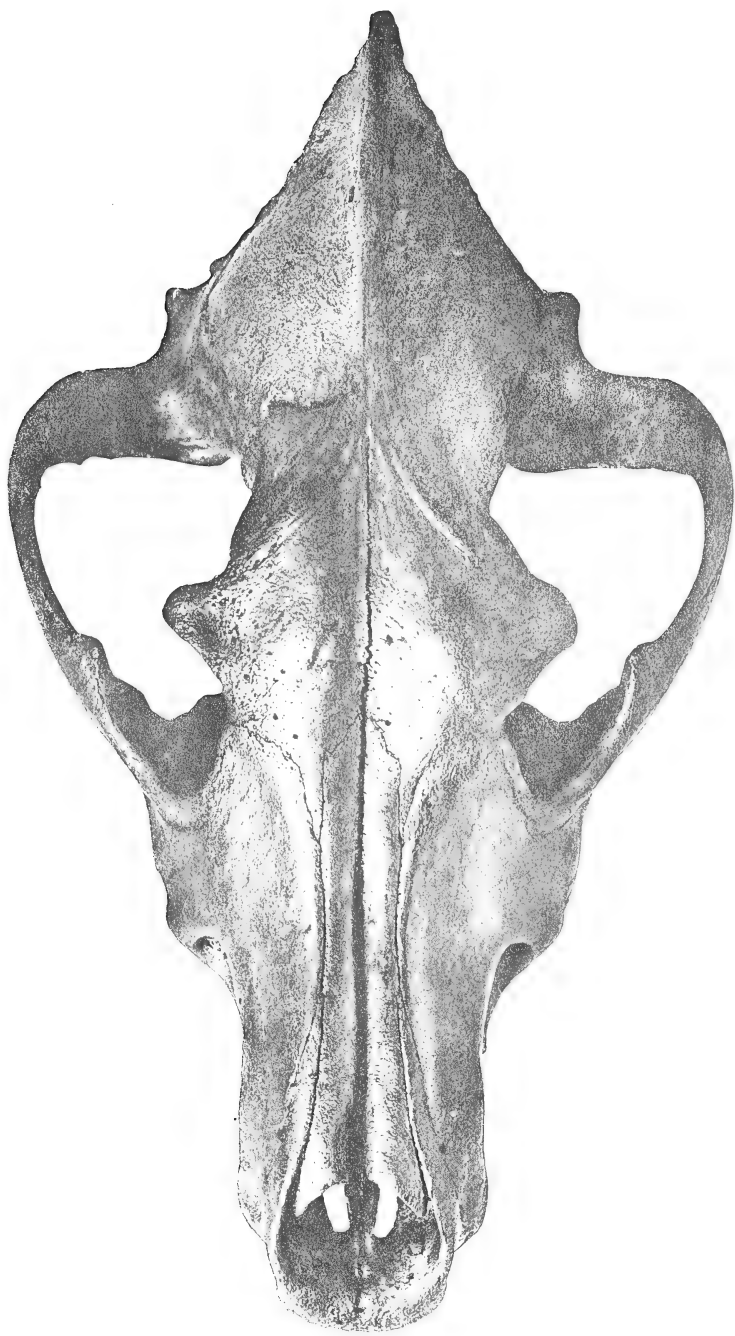Fig. 1. *Canis dirus* Leidy. Skull, no. 10834, lateral view, $\times\frac{3}{5}$. Rancho La Brea Beds

Canis dirus Leidy

Fig. 2. Skull, no. 19796, inferior view, $\times \frac{3}{5}$. Rancho La Brea Beds.
Fig. 3. M^1 and M^2 of the type specimen, natural size.
Fig. 4. M^1 and M^2 of specimen no. 10856, natural size. Rancho La Brea Beds.
Fig. 5. P^3 and M^1 of the Texas specimen described by Cope, natural size.

Canis dirus Leidy.   Skull, no. 12266, superior view, ×⅗.   Rancho La Brea Beds

Canis dirus Leidy. Skull of unusual relative breadth, no. 19796, superior view $\times \frac{3}{5}$. Rancho La Brea Beds
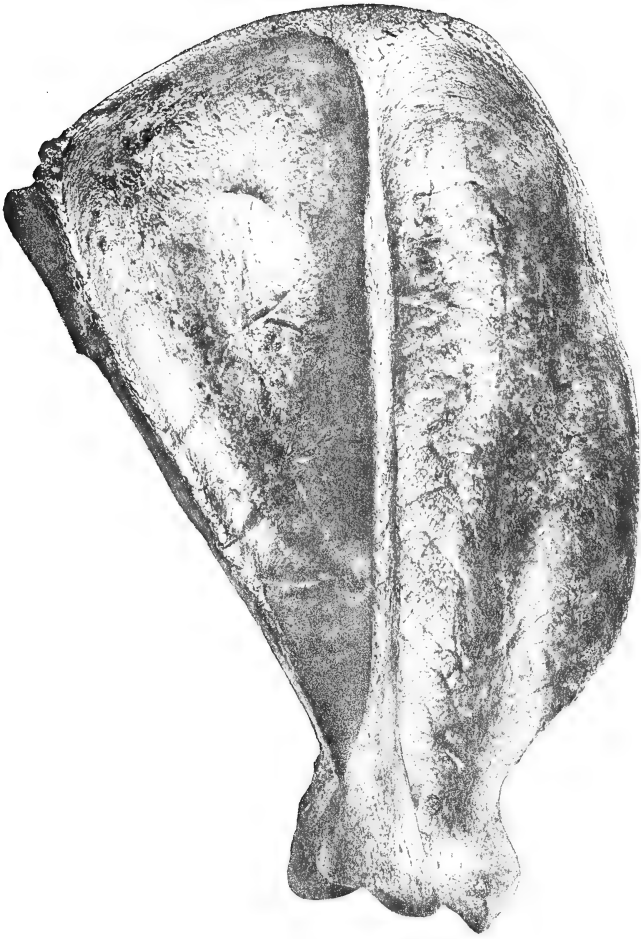
Canis dirus Leidy.   Scapula, outer side, no. 12963, $\times \frac{3}{5}$.   Rancho La Brea Beds
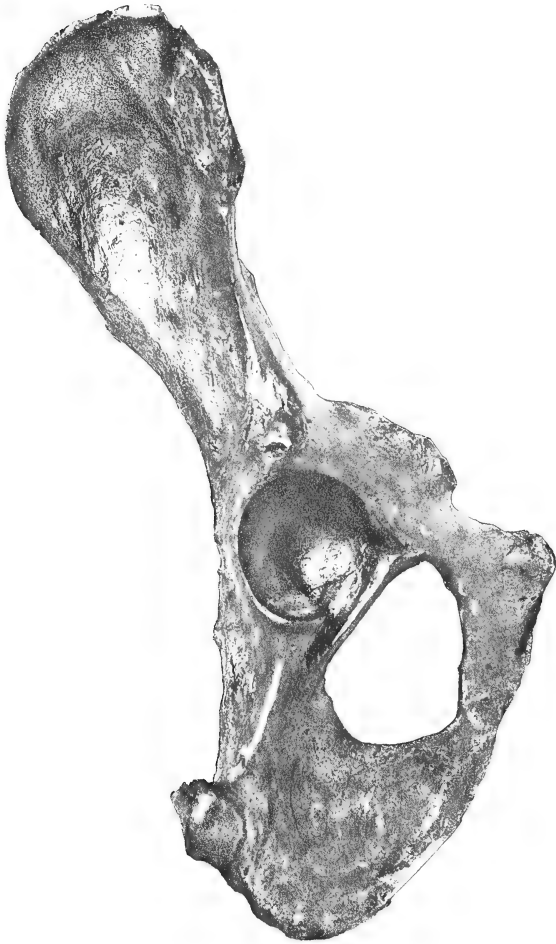
Canis dirus Leidy. Pelvis, outer side, no. 19377, × 3/5. Rancho La Brea Beds

1

Humerus, anterior view

2

Ulna, lateral view

3

Radius, anterior view

Canis dirus Leidy.   Rancho La Brea Beds

Figures approximately three-fifths natural size
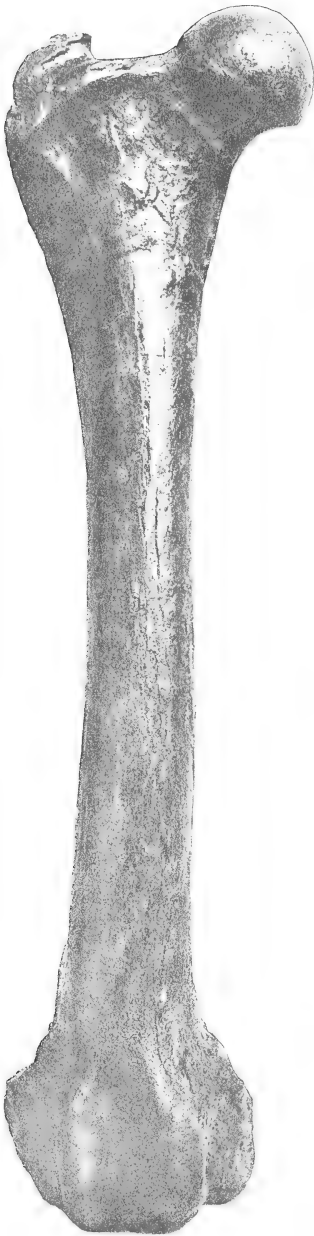
4
Femur, anterior view
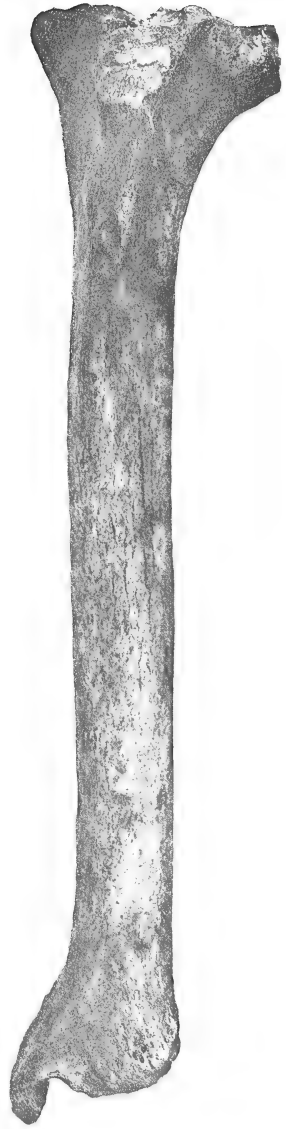
5
Tibia, anterior view

Canis dirus Leidy.   Rancho La Brea Beds

Figures approximately three-fifths natural size

THE SKULL AND DENTITION OF A CAMEL FROM THE PLEISTOCENE OF RANCHO LA BREA

CONTENTS

INTRODUCTION

ALTHOUGH remains of camels are fairly common in the Pleistocene of North America, and are widely distributed over the continent, up to the present time the material obtained has been very fragmentary, and the available information correspondingly unsatisfactory. So far as known to the writer, the best specimens described consist of small parts of the skeleton, the skull being represented by jaws and very incomplete cranial material.

Owing to the nature of the material available, the North American Pleistocene Camelidae have almost necessarily been described under numerous generic and specific names, as the fragmentary specimens representing different parts of the skeleton cannot be correlated satisfactorily. Not less than six genera are listed. It is probable that three of the generic groups have a valid basis in American material. The others are of doubtful value. The forms referred to *Eschatius* and *Camelus* represent two of the generic groups. The relationships of the species referred to *Camelops*, *Megalomeryx*, *Auchenia* and *Holomeniscus*, present one of the problems in the study of this group, recent writers generally considering the four as representing a single genus.

Wortman[1] in his revision of the extinct Camelidae of North America called attention to the very fragmentary nature of the material upon which all of the North American Pleistocene species rest, and considered that no evidence had been presented showing that valid characters separated the genera *Megalomeryx* and *Holomeniscus* from *Camelops*, the first genus described. The North American forms referred to *Auchenia* he showed to be distinct from the Recent *Auchenia*, and not clearly separable from *Camelops*. *Megalomeryx* was described from Nebraska later than *Camelops* from Kansas, and may be of Tertiary age. It was based upon two molar teeth, while the type of *Camelops* consisted of an anterior end of the rostral region without cheek teeth. *Holomeniscus* was characterized by Cope as possessing a single superior premolar, P^4. Wortman stated that, so far as he had been able to obtain information, in the only specimen in which the superior premolar formula can be determined, both P^3 and P^4 are present. So far as determined by Wortman, no characters were presented which might reasonably be considered as distinguishing *Holomeniscus* from *Camelops*.

In the excavation work done at Rancho La Brea during the past six years camel material has been found occasionally, but not until recently has it been possible to obtain a complete skull. In the excavations of the last few months, the University of California has been so fortunate as to find several nearly perfect skulls, and associated with them is a quantity of skeletal material representing the greater part of the animal. Three skulls now available in the palaeontologic laboratory furnish for the first time a satisfactory basis for comparative study of the skull and dentition of our American Pleistocene camels. In advance of an investigation of the entire representation of the skeleton the following descriptions are presented. A discussion of the skeleton will be furnished after completion of the excavation work, when all materials of this group can be brought together for more satisfactory study.

Skull

The skull in specimens 20040, 20028, and 20049 approximates the size in that of the Bactrian camel. The general outlines resemble *Auchenia* more nearly than *Camelus*. In superior view (figs.

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[1] Wortman, J. L., Bull. Am. Mus., vol. 10, p. 128, 1898.

1 and 4), the slender rostral region tapers more gradually toward the anterior end than in *Camelus*, and in this respect resembles *Auchenia*. The frontal region is quite distinctly convex transversely, with no median depression, and in this character differs from the specimens of both *Auchenia* and *Camelus* available for comparison. The orbits are situated relatively far back, the anterior border being situated above the last superior molar. The basicranial and basifacial axes are nearly parallel, as in *Camelus*.

The nasal elements are long and narrow, the posterior ends are separated by a wedge of the frontals, but the outer borders do not spread widely as in *Auchenia* and *Camelus*. The anterior ends of the nasals are in broad contact with the premaxillaries, as in *Auchenia*. The nasals are relatively longer and narrower than in *Auchenia*, and the notch for the posterior border of the anterior nasal opening is not behind the posterior end of the premaxillaries. In *Auchenia* the posterior ends of the premaxillaries do not extend as far back as the posterior border of the anterior nasal opening. The ends of the nasals project anteriorly beyond the superior border of the premaxillaries.

A characteristic feature of the Rancho La Brea specimens is the presence of a large, deep fossa near the upper margin of each maxillary above the fourth premolar (fig. 5). The inferior region of this fossa is not sharply marked. The upper wall of the cavity is abrupt in no. 20040 and is bordered by a sharp overhanging ridge in nos. 20028 and 20049. This fossa is clearly shown in *Pliauchenia* (*Megatylopus*) *gigas* described by Matthew and Cook[2] and is strongly marked in *Alticamelus*.[3] There is no suggestion of it in *Auchenia* or in *Camelus*.

The lachrymal vacuities are very large and have an approximately triangular outline. In specimen 20028 the lachrymals are separated externally from the lachrymal vacuities on one side by the union of the maxillaries and frontals. In no. 20040 they barely touch the vacuities.

The heavy anterior end of the zygomatic process of the squamosal extends forward well beneath the posterior border of the orbit somewhat as in *Auchenia*, but in contrast to the form in *Camelus*. The jugal is much thicker vertically below the orbit than in

[2] Matthew, W. D., and Cook, H. J., Bull. Am. Mus. Nat. Hist., vol. 26, p. 397, 1909.
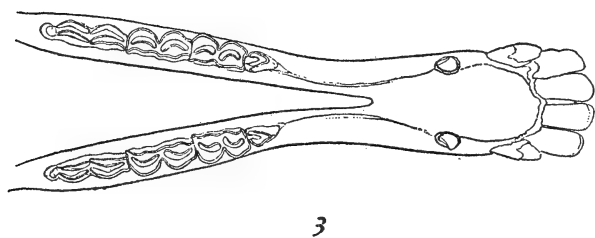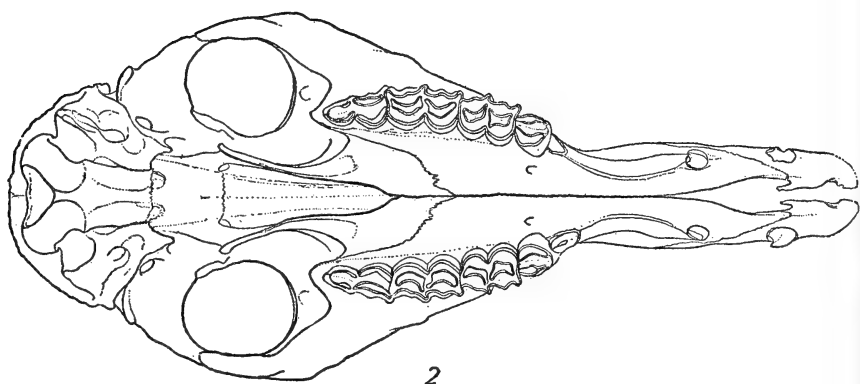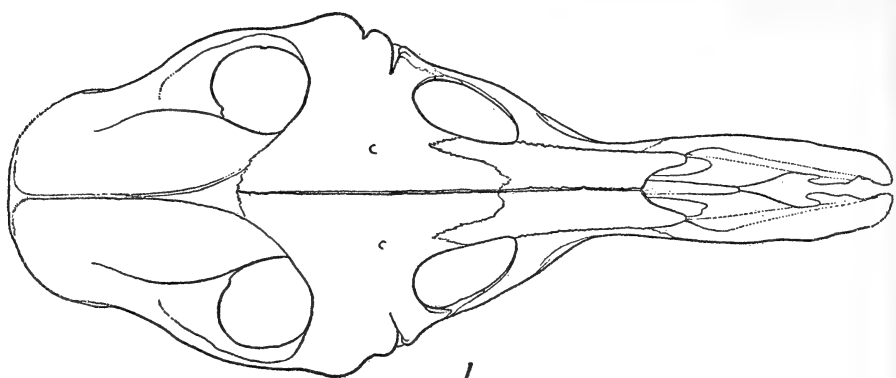[3] *Ibid.*, p. 403.

FIG. 1. *Camelops hesternus* (Leidy). Skull, superior view. No. 20040, × 0.19. Rancho La Brea Beds.

FIG. 2. *Camelops hesternus* (Leidy). Skull, inferior view. No. 20040, × 0.19. Rancho La Brea Beds.

FIG. 3. *Camelops hesternus* (Leidy). Superior view of anterior portion of the mandible with dentition. No. 20040, × 0.19. Rancho La Brea Beds.
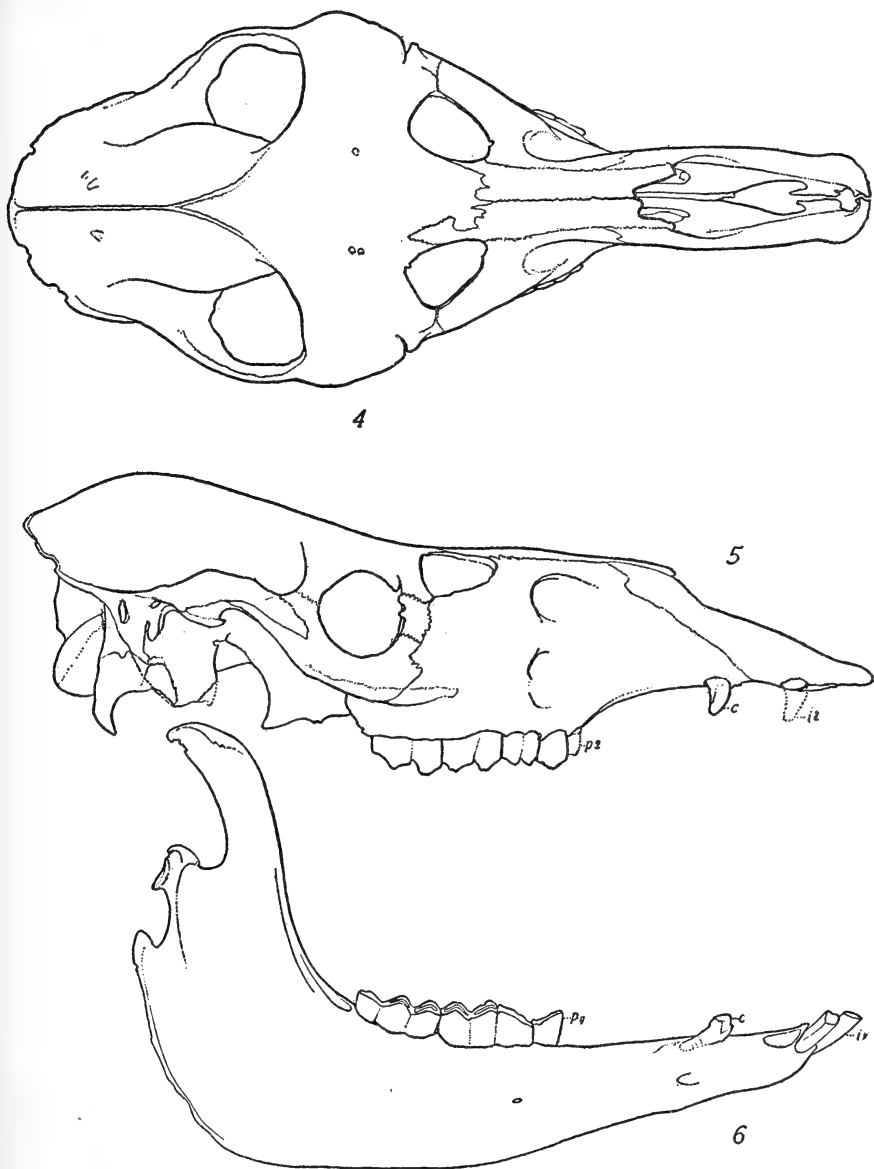
Fig. 4. *Camelops* near *hesternus* (Leidy). Skull, superior view. No. 20028, × 0.19. Rancho La Brea Beds.

Figs. 5 and 6. *Camelops* near *hesternus* (Leidy). Skull. No. 20028, × 0.19. Rancho La Brea Beds. Fig. 5, cranium, lateral view; fig. 6, mandible, lateral view.

Camelus, and exhibits a marked inferior crest or ridge as described in *Megatylopus gigas* by Matthew and Cook.[4]

The palate is narrow (figs. 2 and 9), the long, narrow, V-shaped posterior nasal opening extending forward to a point slightly in advance of a line connecting the middle region of the third upper molars in nos. 20028 and 20049, and to the posterior end of M^2 in no. 20040.

The basisphenoid and presphenoid form a deep narrow ridge quite different from the inferior surface of this element in *Camelus* and in *Auchenia*. The inferior processes of the alisphenoid seem smaller, are less divergent, and do not project as far inferiorly as in *Camelus*.

The glenoid fossa is relatively narrower posteriorly than in *Camelus*, and as in *Auchenia*, the outer margin of this fossa is not bordered by a distinctly elevated wall or process that is seen in *Camelus*. The postglenoid process is somewhat larger than in *Auchenia*.

In specimen 20028 the transverse palato-maxillary suture truncates the anterior ends of the palatines rather broadly, as in *Camelus dromedarius*. In no. 20049 the suture is more strongly convex anteriorly. In no. 20040 it is still more acute anteriorly. In *Auchenia lama* the anterior ends of the palatines extend forward as an acute wedge between the maxillaries.

The paroccipital process is rather slender, and bends forward with a marked inferior hook. In *Auchenia* this process is wider distally. The mastoid region forms a deep and rather narrow plate anteriorly. The mastoid and paroccipital plates are brought nearer together than in either *Auchenia* or *Camelus*. In nos. 20040 and 20028 the posterior inferior border of the mastoid plate slopes forward quite sharply in contrast to the form seen in *Auchenia*.

The occipital region (fig. 7) shows rather more similarity to *Camelus* than to *Auchenia*. In *Auchenia* the occiput consists of two lateral planes which meet in a strong median crest. At the outer borders of these planes are the lateral foramina of the occiput. In the Rancho La Brea specimens there is a short low median crest at the upper end of the occiput in nos. 20028 and 20040; in no. 20049 it is scarcely visible. On each side of the crest is a deep fossa

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[4] *Ibid.*, p. 398.

for the rectus capitis posticus. At either side of the occiput the large lateral foramina lie at the bottom of large, deep fossae, and these foramina deeply notch the margins of the occipital bone. Between the lateral foramina and the fossae for the muscles below the inion the occipital bone rises on each side as a prominent rounded buttress or ridge extending from near the upper border of the foramen magnum to the lambdoidal crest. The region of the occiput immediately above the foramen magnum is moderately convex, approaching flatness, as in *Camelus*, instead of strongly convex nearing angularity, as in *Auchenia*.

The frontal foramina are a little farther apart than in *Camelus*. In *Auchenia* these foramina are relatively larger and there are distinct channels leading forward from them such as are not seen in the Rancho La Brea specimens. The infraorbital foramen and the
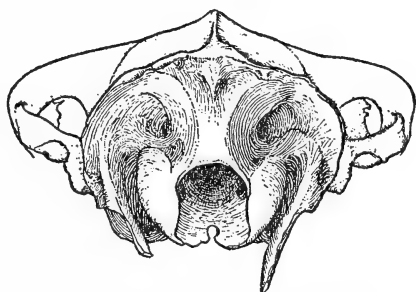

Fig. 7. *Camelops* near *hesternus* (Leidy). Occipital region of the skull. No. 20028, × ⅕. Rancho La Brea Beds.

foramen piercing the root of the zygomatic arch are situated much as in *Auchenia*. The infraorbital foramina consist of a single opening on each side in no. 20028; the opening is separated into two parts by a bridge of bone in 20040; and is divided on one side by a slender bridge in 20049. The infraorbital foramina are situated approximately over the posterior border of P^4 in nos. 20028 and 20040, and over the middle region of M^1 in no. 20049. The anterior palatine foramina are long and narrow, and extend back to the canines. The anterior ends of the maxillaries extending around the borders of these foramina reach to the anterior side of the openings, as in the type of *Camelops*. In *Auchenia lama* they do not reach as far forward. The posterior palatine foramina are situated well forward near P^3 in specimen 20028, and opposite P^4 in nos. 20040 and 20049.

The postglenoid foramen is very small, in contrast to the large size of the opening in *Camelus*. A small foramen present on the outer base of the postglenoid process is not found in *Camelus* and is absent or very minute in *Auchenia*. The lateral foramina of the occiput are very large and open externally into the deep lateral fossae of the occipital region. The anterior mental foramen of the mandible is immediately below or slightly behind the canine, as in *Auchenia*. It is situated farther back on the horizontal ramus in *Camelus*.
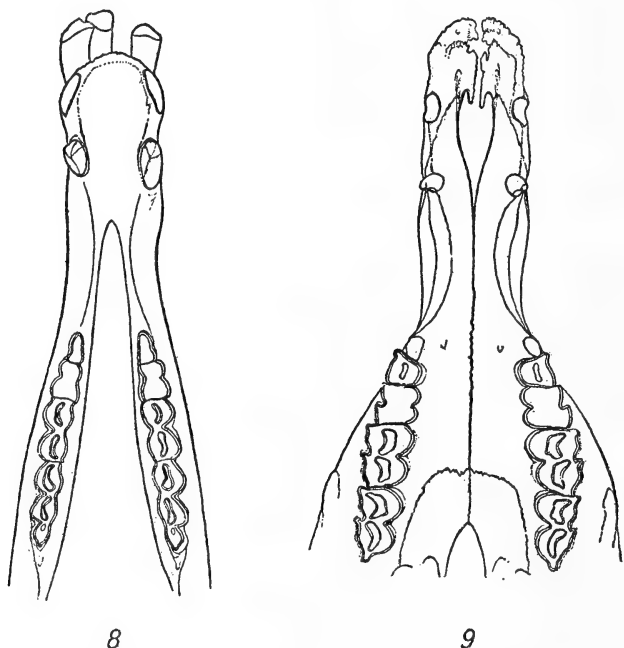

8   9

FIG. 8. *Camelops* near *hesternus* (Leidy). Superior view of anterior portion of the mandible with dentition. No. 20028, × ⅕. Rancho La Brea Beds.

FIG. 9. *Camelops* near *hesternus* (Leidy). Inferior view of anterior portion of the skull with dentition. No. 20028, × ⅕. Rancho La Brea Beds.

See also for dentition, figs. 2 and 3, p. 814.

In the mandible (figs. 3, 6, and 8), the symphysial region is relatively short anteroposteriorly, as in *Auchenia*. The symphysial union in *Camelus* is much longer anteroposteriorly than in *Auchenia* or in the Rancho La Brea specimens. The horizontal ramus is somewhat higher than in *Camelus*, and slightly higher than in *Auchenia*. It tapers very gradually toward the anterior end. Below the diastema the lower margin is barely concave, in contrast

with *Auchenia*, in which it is distinctly concave. In *Camelus* the inferior border may show a distinct concavity between a point below M_3 and the symphysis. The high coronoid process shows a nearly even width or anteroposterior diameter for the greater part of its height.

MEASUREMENTS OF SKULL

	No. 20028	No. 20040
Length, anterior end of premaxillaries to posterior end of occipital condyles	571. mm.	573.
Length, anterior end of premaxillaries to anterior end of inferior nasal opening	316.4	318.
Length along median line, anterior end of premaxillaries to posterior end of superior molar series	341.	362.
Length along median line from anterior border of premaxillaries to plane connecting anterior borders of orbits	324.5	322.
Greatest width at posterior region of orbits	245.	251.
Greatest height of orbits	63.3	61.
Least width of brain-case immediately behind orbits	77.	83.
Least width of rostral region between superior canine and cheek-tooth series	62.9	....
Greatest anteroposterior diameter of right ramus of the mandible	452.	469.
Greatest height of mandible below posterior border of M_3	109.	103.
Height of mandible below anterior border of P_4	60.	61.
Length of diastema between inferior canine and P_4	100.	112.

DENTITION

Dental formula, $I\frac{1}{3}$, $C\frac{1}{1}$, $P\frac{2}{1}$, $M\frac{3}{3}$

The dentition in general shows more resemblance to that of *Auchenia* than to any other form.

I^3 is a little larger than the superior canine. It is a laterally compressed, recurved, lanceolate tooth quite similar to I^3 of *Auchenia*. The lower incisor dentition was of much the same type as in *Auchenia*. I_3 was at least as large compared with I_1 and I_2 as in *Auchenia*; it seems distinctly larger than in *Holomeniscus hesternus* from Texas figured by Cope.[5]

The small superior canines have much the same form as in *Auchenia*, but are relatively thicker transversely.

As in *Auchenia*, small papillae which may be present behind the canines indicate the existence of rudiments of the anterior premolars.

P^3 as shown in no. 20040 (fig. 2) has a narrow, almost blade-like crown with a very small cusp, or a prominent ridge of the

[5] Cope, E. D., Geol. Surv. Texas, 3rd Ann. Rep. for 1891, pl. 21, fig. 4.

cingulum high up on the postero-internal wall. It shows approximately the same size compared with P^4 that is noted in *Auchenia*.

P^4 has a relatively greater transverse diameter than in *Auchenia* and a more distinctly quadrate form. In this respect, it more closely approaches the form seen in *Camelus*.

Lower premolar four has approximately the same relation to M_1 in dimensions as in *Auchenia*. It has a wedge-shaped cross-section and approximates the form in *Auchenia*. There is a deep enamel fold on the posterior side of the crown, as in *Auchenia*, but the inner or medial side is an almost even vertical wall without the folds seen in *Auchenia*. P_4 shows some evidence of division of the root into two parts, and a faint groove on one side may mark the line of separation.

The upper molars all differ somewhat from those of *Auchenia* in the less marked development of the external styles and of the median ribs on the outer side of the paraconid and metaconid. In M^2 the anterior lobe has a noticeably greater transverse diameter than the posterior lobe. On the somewhat worn M^3 of no. 20028 the metastyle is drawn out posteriorly as a wing not shown in *Auchenia*. This wing does not appear in the unworn M^3 of no. 20040.

In M_1 and M_2 the inner walls of the protoconid and hypoconid lobes tend to be a little more distinctly separated by a median longitudinal groove than in *Camelus*. The styles and inner ribs of the lower molars are less strongly developed than in *Auchenia*. M_2 and M_3 differ markedly from the corresponding teeth of *Auchenia* in the absence of the anteroexternal buttresses so characteristic of that genus. It is upon this character that Wortman[6] separates *Camelops* from *Auchenia*. M_3 is distinguished from that of *Camelus* by the position of the posterior or third lobe. In the Rancho La Brea specimens this lobe extends nearly straight back, and its inner wall is nearly even with that of the anterior lobes of this tooth. In *Camelus* the inner wall of the posterior lobe turns sharply out and away from the nearly even plane formed by the inner walls of the first and second lobes. In *Auchenia* the posterior lobe of M_3 rises from approximately the middle of the posterior end of the second lobe, and is separated from the inner and outer walls of the second lobe by a deep longitudinal groove on each side.

[6] Wortman, J. L., Bull. Am. Mus. Nat. Hist., vol. 10, pp. 129–130, 1898.

Measurements of Dentition

	No. 20028	No. 20040
Length, anterior side of I^1 to posterior side of M^3, measured along outer border of dental series	301. mm.	327.
Length, anterior side of P_4 to posterior side of M_3	141.9	
Length, anterior side of inferior canine to posterior side of M_3	250.	290.
Greatest width of palate between outer borders of superior cheek-tooth series (measured between outer borders of third molars)	141.9	148.
Least transverse diameter of palate between superior cheek-tooth series (measured between inner borders of fourth premolars)	66.	56.
Length, anterior side of P^4 to posterior side of M^3	142.7	156.4
Length, anterior side of M^1 to posterior side of M^3	124.	132.
I^3, anteroposterior diameter		17.8
I^3, greatest transverse diameter		9.7
Superior canine, anteroposterior diameter	13.9	13.2
P^3, anteroposterior diameter		18.8
P^3, greatest transverse diameter		11.
P^4, anteroposterior diameter	23.5	*28.
P^4, greatest transverse diameter	25.	22.5
M^1, anteroposterior diameter	24.4	42.
M^1, greatest transverse diameter	31.	33.6
M^2, anteroposterior diameter	42.1	52.
M^2, greatest transverse diameter across protocone	31.6	32.8
M^3, greatest anteroposterior diameter	49.5	45.8
M^3, greatest transverse diameter	31.4	27.2

	Type of C. hesternus	Cope's Texas specimen§	No. 20028	No. 20040
Length, anterior side of P_4 to posterior side of M_3		‡164.	142. mm.	†162.2
I_1, greatest transverse diameter		a13.	17.9	19.
I_2, greatest transverse diameter		19.	20.4	18.8
I_3, anteroposterior diameter of alveolus		12.	28.5	25.3
Inferior canine, greatest anteroposterior diameter		a12.	16.1	
P_4, greatest anteroposterior diameter	27.	27.	21.9	27.5
P_4, greatest transverse diameter			12.9	13.4
M_1, anteroposterior diameter	42.	38.	28.	39.
M_1, greatest transverse diameter			21.1	21.5
M_2, anteroposterior diameter	52.	44.	38.4	46.
M_2, greatest transverse diameter			22.	21.2
M_3, greatest anteroposterior diameter	58.	56.	58.2	58.
M_3, greatest transverse diameter across anterior lobe			21.6	18.5

a, approximate.
* at base of crown.
† M_3 not completely emerged.
‡ From Cope's figure of the specimen.
§ Cope, E. D., Geol. Surv. Tex., 3rd Ann. Rep. for 1891, pl. 21, figs. 3 and 4.

Relation of Rancho La Brea Specimens to Previously Described Pleistocene Forms from North America

It is perhaps undesirable at this stage in the study of the Rancho La Brea camels to attempt a final determination of their relationships to all of the known North American forms, but the broader outlines of the problem may be presented.

The Rancho La Brea specimens so far as known are clearly distinguished from the American Pleistocene species referred to the genera *Eschatius* and *Camelus*. They are separated from both *Camelus* and *Eschatius* by their dental formula of $\frac{1}{3}, \frac{1}{1}, \frac{2}{1}, \frac{3}{3}$.

In the mandible from Hay Springs referred by Wortman[7] to the genus *Camelus* the formula is $\overline{3}, \overline{1}, \overline{2}, \overline{3}$; the inferior canine is more or less incisiform, and is not separated from I_3 by a marked diastema; and P_1 is caniniform.

The genus *Eschatius* is characterized by the most extreme reduction known in the cheek-tooth dentition, the formula of the upper series being $P^1 M^3$. P^3 is not represented, and P^4 is reduced to a simple conical form not unlike the small P^3 of the Rancho La Brea specimens.

The American Pleistocene forms with which the Rancho La Brea specimens are most closely related are those included in the species that have been referred to *Camelops*, *Auchenia*, and *Holomeniscus*.

Comparison with Type Specimens of Camelops.—Leidy's type of *Camelops* consisted of the anterior end of a premaxillary bone with the root of the last upper incisor, and a small piece of the maxillary, with the alveolus of the canine (figs. 10*a* and 10*b*). Compared with this specimen, the anterior end of the rostral region of the Rancho La Brea skulls shows little to distinguish it. The general proportions of the elements present and the location of the teeth are nearly the same. The extension of the maxillary forward around the anterior end of the anterior palatine foramen noted in the Rancho La Brea specimens is much as in the type of *Camelops*.

Comparison with the Type Specimen of Auchenia hesterna Leidy.—The type specimen of *Auchenia hesterna* was discovered by Dr. Lorenzo G. Yates in Livermore Valley, California, in a gravel deposit which was presumed by Dr. Yates to represent an old river

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[7] Wortman, J. L., Bull. Am. Mus. Nat. Hist., vol. 10, p. 133, 1898.

channel. A statement by Leidy, based upon the communication of Professor E. O. Hovey, to the effect that it was found twenty-five miles inland from San Leandro, California,[8] is erroneous, according to Dr. Yates.[9]

The type consists of a lower molar series and a single upper molar. There is some uncertainty as to whether these teeth all represent the same individual. The fact that the relative stages of wear are approximately what one might expect to find in the

10a

10b
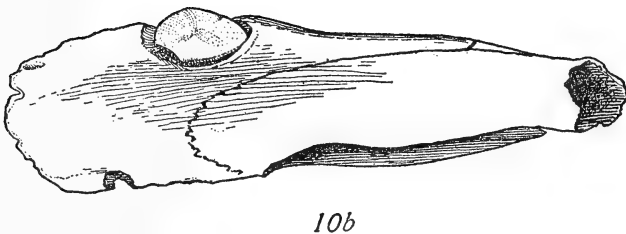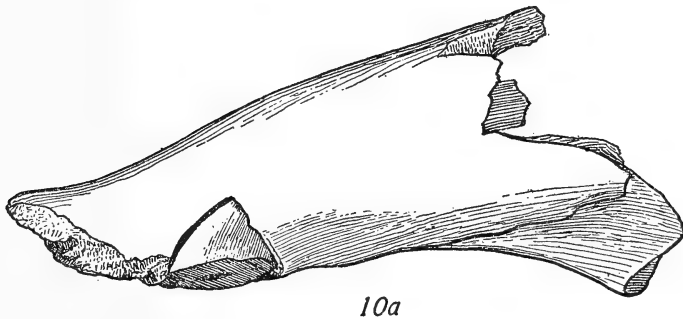
FIGS. 10a AND 10b. *Camelops kansanus* Leidy. Type specimen, adapted from Leidy, natural size. Fig. 10a, anterior end of rostral region, lateral view; fig. 10b, anterior end of rostral region, inferior view.

same series is evidence in favor of the view that the lower teeth are all from one animal.

The dentition of the Rancho La Brea specimens resembles that of the type of *Auchenia hesterna* in the presence of a single premolar, P_4, with a wedge-shaped cross-section. The general form and relative dimensions of this tooth are much the same in the type of

[8] Leidy, J., Geol. Surv. Terr., vol. 1, Fossil Vertebrates, pp. 228, 229, 256, 1873.
[9] Yates, L. G., Proc. Acad. Nat. Sci., Philad., vol. 26, p. 18, 1874.

A. hesterna and in specimen 20040 from Rancho La Brea. The nature of the posterior enamel fold of the crown is similar in the two. In the type of *A. hesterna* (Leidy, pl. 37, fig. 2) P_4 is represented with a distinct groove on the outer side marking the division of the tooth into anterior and posterior regions, each terminating inferiorly in a distinct root. In Rancho La Brea specimen 20028 there is an exceedingly faint separation of the two roots, and the
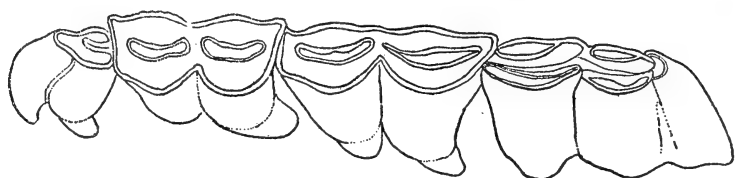
11a
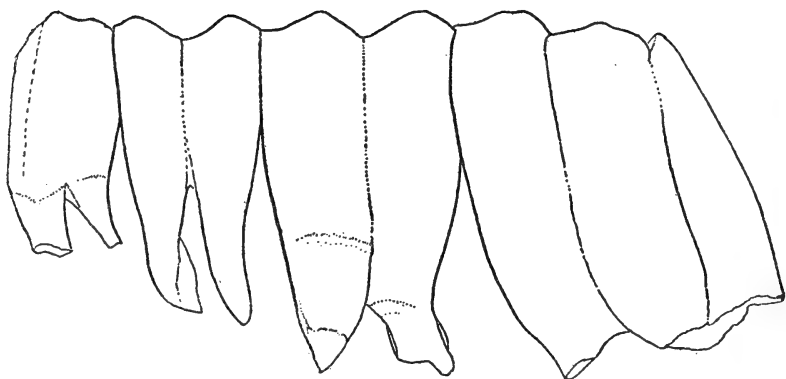
11b

FIGS. 11a AND 11b. *Camelops hesternus* (Leidy). Inferior cheek-tooth series of type specimen, × ½. Fig. 11a, occlusal view; fig. 11b, lateral view. (Adapted from Leidy.)

inner face of the crown may show a faint groove, marking this division; there is, however, no external groove as represented for *A. hesterna*. In Leidy's figure 1 of the plate to which reference is made above the identical P_4 represented in figure 2 seems to show almost no external groove.

In the type of *Auchenia hesterna*, M_1 and M_2 are both very considerably larger than in specimen 20028, and M_2 seems relatively

much larger, especially compared with M_3. In specimen 20040 the dimensions of P_4 and M_3 are practically identical with those in the type of *A. hesterna*. M_1 is only seven per cent smaller, and M_2 eleven per cent smaller. The slight differences between specimen 20040 and the type of *A. hesterna* seem to the writer of less than specific value, and the Rancho La Brea form may be considered as typifying that species. The differences between nos. 20040 and 20028 are greater than between 20040 and the type of *hesterna*, but considering the close similarity in form and dimensions of the skull, together with the evident difference in age of the two individuals, the writer is not inclined to believe the difference in tooth measurement as of specific rank. No. 20028 represents a much older animal than no. 20040. During a considerable period in the life history of each individual P_4 and M_3 increase in anteroposterior diameter of the crushing face as the crowns wear down; while M_1 and M_2, with crowns narrowing inferiorly much earlier than the other teeth, shorten the anteroposterior diameter of the occlusal surface. There seems also to be some individual variation in tooth dimensions, so that age, with sex and individual variation, may produce rather large differences in relative size of the teeth.

The upper molar of *Auchenia hesterna* figured by Leidy does not differ greatly from M^2 of the Rancho La Brea form.

A California species described by Leidy[10] as *Auchenia californica* previous to the publication of *A. hesterna* may be identical with *hesterna*, and may therefore include the specimens here described. This can best be determined by a careful comparative study of all skeletal material obtained, as *A. californica* was based solely upon limb and arch bones of very large size. If we give full value to the statement on the label accompanying the type specimen of *A. californica*, to the effect that it came from beneath the lavas at Table Mountain, it is probable that this species is of Tertiary age, and presumably specifically if not generically distinct from the Rancho La Brea form.

Comparison with Texas Forms Referred to by Cope as Holomeniscus hesternus, H. sulcatus, H. vitikerianus, and H. macrocephalus.—A fine mandibular ramus from Bowie Bend, Austin County, Texas,

[10] Leidy, J., Proc. Acad. Nat. Sci., Phila., 1870, p. 126.

was considered by Cope[11] to represent the same species as the type of Leidy's *Auchenia hesterna*. Cope's specimen is undoubtedly near *hesterna*, and resembles it more closely in the dimensions of M_1 and M_2 than does specimen no. 20028 from Rancho La Brea. The reference of this specimen to *hesterna* by Cope on the basis of evidence then available seems justified.

Compared with Cope's Texas type of *Holomeniscus hesternus* the specimens from Rancho La Brea show a slightly larger mandible with more widely spreading incisors and a larger I_3. As nearly as can be determined, I_3 of the Rancho La Brea specimens is much larger compared with I_2 than in the Texas form. The dimensions of the cheek-teeth are closely similar in Cope's specimen and no. 20040 from Rancho La Brea. The Texas specimen and those from Rancho La Brea are evidently generically identical. The characters separating them are doubtfully of specific rank. The determination of the exact specific relationship of these two forms may well await an examination of all possible collections from Rancho La Brea, to determine the limits of variability of the California form.

A specimen from Tequixquiac, Mexico, described by Cope[12] is near the form from Texas.

Holomeniscus sulcatus Cope from Texas is near the Rancho La Brea species in many characters. The type of *H. sulcatus* is an old individual with worn P_4 and M_1, and measurements of the dentition are very close to those of no. 20028 from Rancho La Brea, in which the teeth give evidence of a similar stage of wear. As has been suggested by Wortman, the peculiar characters of this species may be shown later to come within the limits of individual or age variations of one of the previously described forms, like *Camelops kansanus* or *C. hesternus*.

The Pleistocene species described by Cope as *Auchenia vitikeriana*[13] and *Holomeniscus macrocephalus*[14] are possibly generically identical with the Rancho La Brea species, but are specifically distinct. The form of the posterior lobe of M_3 in *H. macrocephalus* is quite different from that of *Camelops hesternus*.

[11] Cope, E. D., Geol. Surv. Texas, 3rd Ann. Rep. for 1891, pp. 71 and 85.

[12] Cope, E. D., Amer. Phil. Soc. Proc., vol. 22, p. 18, May 16, 1884.

[13] Cope, E. D., Bull. U. S. Geol. and Geog. Surv. Terr., vol. 4, p. 380, 1878.

[14] Cope, E. D., Geol. Surv. Texas, 3rd Ann. Rep. for 1891, p. 85 and pl. 23, figs. 5 and 5*a*.

SUMMARY

The Rancho La Brea form seen in specimens nos. 20040 and 20028 closely resembles as much as is known of the type specimen of *Camelops* Leidy. Although no satisfactory generic description of *Camelops* was given by Leidy, it is probable that the Rancho La Brea specimens represent the same generic group as the type specimen. Rancho La Brea specimen no. 20040 is evidently generically and specifically identical with Leidy's type of *Auchenia hesterna*. It is also generically identical with Cope's specimen identified as *Holomeniscus hesternus*, from Texas. Cope's type of *Holomeniscus sulcatus* is evidently in the same generic group. *Holomeniscus vitikerianus* presumably belongs in the same genus with the species just mentioned, and possibly also *H. macrocephalus*.

As shown by Wortman the separation of the North American Pleistocene camels from *Auchenia* is justified on the basis of differences in the form of the inferior molars, and the characters given by Cope to *Holomeniscus* are not distinctive. For the present at least the writer adopts the suggestion of Wortman that the name *Camelops* should be used for the group of species represented by *C. kansanus* and *C. hesternus*, since it is the earliest designation applied.

The group of camels referred to *Camelops*, and represented by specimens nos. 20040 and 20028 from Rancho La Brea, is much nearer to *Auchenia* than to *Camelus*, but is nevertheless distinct from the typical *Auchenia*. It is separated from *Camelus* by the premolar formula of $\frac{2}{1}$, instead of $\frac{3}{2}$, relatively small size of P³, broad contact of the nasals and premaxillaries, presence of well-defined maxillary fossae, relatively great anterior extension of the zygomatic process of the squamosal, absence of a lateral bordering wall on the glenoid fossa, and the higher mandible which tapers more gradually anteriorly.

The *Camelops* group as here comprised resembles *Auchenia* in the general form of the skull and especially of the mandible, the relation of the nasals and premaxillaries, relatively great anterior extension of the zygomatic process of the squamosal, form of the glenoid fossa, and in premolar formula. The group differs from *Auchenia* in the form of the frontal region, narrower nasals, presence of large maxillary fossae, form of the mastoid process, more nearly quadrate form of P⁴, more distinctly wedge-shaped cross-

section of P_4, absence of folds on medial side of P_4, less marked development of styles and ribs on outer side of upper molars and inner side of lower molars, and absence of strongly marked antero-external styles in M_2 and M_3.

Although a definite statement as to the affinities of *Camelops* would be premature if presented in advance of a study of the entire skeleton, it seems desirable to call attention to the resemblance in characters of skull and dentition in the Rancho La Brea form to those of *Pliauchenia* (*Megatylopus*) of Matthew and Cook.[15]

[15] Matthew, W. D., and Cook, H. J., Bull. Amer. Mus. Nat. Hist., vol. 26, pp. 396–401, 1909.

PRELIMINARY REPORT ON THE HORSES OF RANCHO LA BREA

CONTENTS

INTRODUCTION

REMAINS of horses have been obtained in considerable numbers from the Pleistocene beds of Rancho La Brea, but not until within the last year has skull material been found in such quantity as to make possible a critical study in which the important factors of individual and age variation could be considered with any degree of satisfaction. In the excavations recently carried on through the kind permission of the late Madam Hancock Ross, and her son, Mr. G. Allan Hancock, a number of good skulls have been obtained, with much material consisting of loose teeth and elements representing all parts of the skeleton. These collections, together with several skulls and much scattered material already available, offer one of the fullest opportunities for study of American Pleistocene horses that has been presented. Satisfactory preparation and examination of the entire series of specimens will require many months' work. In advance of this study it is possible to give such a statement of the most important

contributions made by this collection as will assist in the interpretation of other material.

The collection available contains eleven good skulls, several imperfect specimens, and much fragmentary material. It represents animals of both sexes, and of all ages from foals with unworn milk teeth to old individuals with dentition in advanced stages of wear. The specimens show considerable variation in the characteristics upon which our classification of American Pleistocene horses has of necessity been largely based, and an estimation of the significance of this variation will presumably assist to some extent in interpretation of a number of the numerous imperfectly known equine species described from the American Pleistocene.

Up to the present time the only descriptions of satisfactory skull material representing American Pleistocene horses are those of Gidley[1] on *Equus scotti* of the Texas Pleistocene, and Hay[2] on *Equus niobrarensis* and *Equus laurentius* from Nebraska and Kansas. Of *Equus scotti* several skulls representing individuals ranging from youth to maturity are available. Skeletal material accompanying the skulls gives to this species a full and satisfactory representation. Of *Equus laurentius* the single good skull known shows this form, with its slender skull and small teeth, to be distinctly separated from the heavy-headed *E. scotti* and *E. niobrarensis*. Of *Equus niobrarensis* an imperfect skull from Hay Springs, Nebraska, shows most of the characteristics satisfactorily excepting the frontal and facial regions. Another specimen from the Pleistocene of Tofty, Alaska, is referred to a subspecies, *Equus niobrarensis alaskae* by Hay. The lower jaws of this form were not found. The cranium lacks only the nasal region. *Equus niobrarensis* is distinguished from *Equus laurentius* by its shorter and wider nose, heavier and anteriorly much higher mandible. The teeth are larger and wider than in *Equus laurentius*. From *Equus scotti* this species seems to be distinguished by its smaller teeth.

Before the discovery of specimens at Rancho La Brea no good skulls and no complete skeletal specimens representing Pleistocene horses were known from the Pacific Coast region.

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[1] Gidley, J. W., Bull. Am. Mus. Nat. Hist., vol. 13, pp. 111 to 116, 1900.

[2] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44, pp. 576 to 591, 1913; and Smithsonian Misc. Coll., vol. 61, no. 2, 1913.
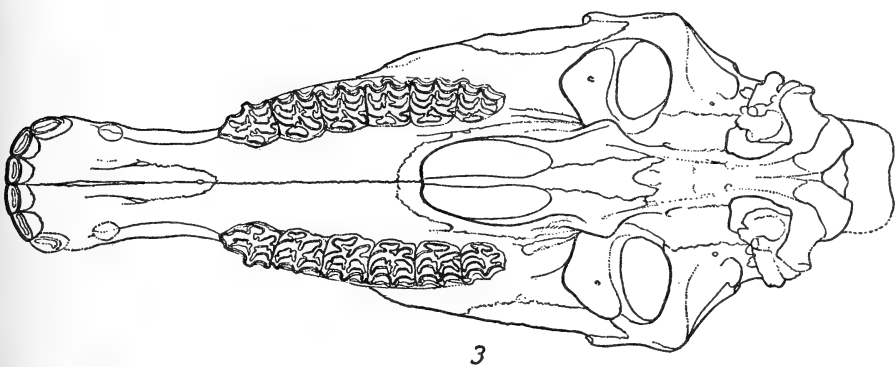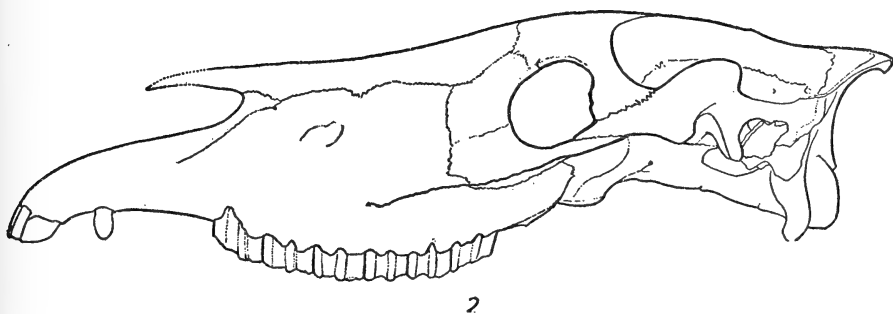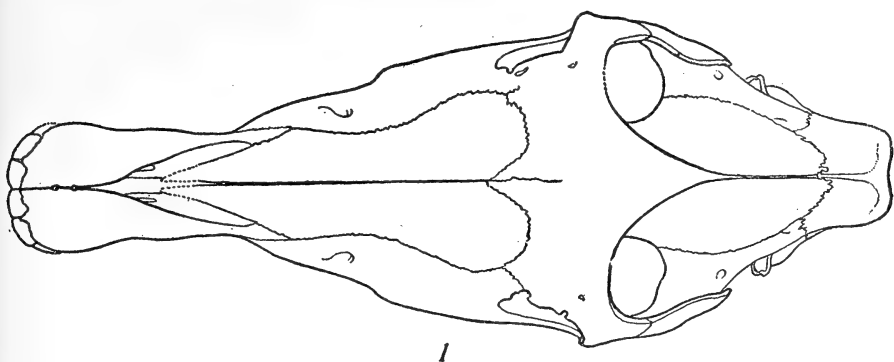
FIGS. 1 TO 3. *Equus occidentalis* Leidy.   Skull, no. 20097, × 0.19.   Rancho La Brea Beds, California.   Fig. 1, superior view; fig. 2, lateral view; fig. 3, inferior view.

Skull

The eleven practically complete horse crania from Rancho La Brea naturally show certain variations in form and size, but they are so near together in the assemblage of their characters, and present such gradations through the series, that there seems good reason for considering them all as one species, and they are treated by the writer as forms of a single specific type.

The skulls from Rancho La Brea equal or exceed those of the Recent *Equus caballus* in size. Compared with *E. caballus* the face is relatively a little wider, and the nose is relatively short and wide. The notch between the nasals and premaxillaries is wider or less acute posteriorly than in *E. caballus*. In profile the superior fronto-nasal surface is generally nearly flat, or very slightly concave above the middle of the nasals. Between the
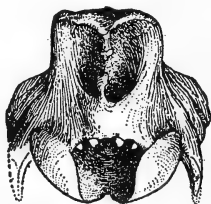

Fig. 4. *Equus occidentalis* Leidy. Posterior view of skull. No. 21002, $\times \frac{1}{5}$. Rancho La Brea Beds, California.

orbits the frontal region is in most specimens slightly more convex transversely than in *E. caballus*. This seems to be true in stages ranging from young adults to individuals of fairly advanced age. The nasals are relatively wide, and their anterior ends reach forward to a point a little behind the superior canines.

The orbits are near the size of those in *E. caballus*, but tend to be slightly larger. They are noticeably smaller than in *E. niobrarensis* and *E. laurentius*.

The occiput is higher and narrower than in the domestic horse, and the overhang of the inion is considerably greater. The greatest width across the condyles averages relatively smaller than in *E. caballus*.

The mandible is heavy in contrast with that of the modern horse, and the horizontal ramus is much higher below the anterior cheekteeth and below the diastema. The symphysial region is relatively

wide.   The mandible of a specimen (no. 21000), tentatively referred to *E. occidentalis*, shows unusual width anteriorly.   The inferior border is usually distinctly convex below the anterior cheek-teeth, and may show a slightly concave region below the posterior molars.

MEASUREMENTS OF SKULL

	E. caballus	E. occidentalis No. 2097 a Rancho La Brea	E. occidentalis No. 2008 b Rancho La Brea	E. occidentalis No. 19832 c Rancho La Brea	No. 2009 d Rancho La Brea	E. niobrarensis Type	E. laurentius Type
Anterior end of premaxillaries to posterior end of occipital condyles........	568 mm.	555.	583.	589.	537.	556.	....
Anterior end of premaxillaries to inferior margin of foramen magnum.....	538.	527.	555.	558.	507.	530.	481.
Anterior end of premaxillaries to a line connecting anterior border of second upper premolars.........	155.	121.	138.	136.	127.	137.	128.
Anterior end of premaxillaries to a line connecting posterior border of last upper molars............	318.	312.	335.	313.	....	....	294.?
Anterior end of premaxillaries to a line connecting anterior border of orbits..	344.	319.	345.	334.	305.	340.	293.
Anterior end of premaxillaries to a line connecting posterior border of orbits.	391.	370.	417.	399.	364.	400.	....
Least width across rostrum.	58.3	71.8	68.8	75.5	60.6	....	....
Width of skull on maxillary ridge at maxillo-malar suture....................	188.	176.	184. *ap.*	190. *ap.*	158.	187.	....
Greatest width across posterior border of orbits....	208.	218.	219.	227.	196.	240.	207.
Width between outer sides of second upper premolars..	103.5	110.	115.3	113.1	99.3	....	....
Width between outer sides of last upper molars........	126.5	119.6	123.	129.6	....	123.	132.
Greatest anteroposterior diameter of orbits.........	57.5	63.	64.6	$\begin{cases} 60.9\ l \\ 69.7\ r \end{cases}$	61.4	84.	65.
Height of occiput above base of occipital condyles.....	106.	111.	104.	127.8	127.	....	....
Least width of occiput below superior crest........	69.5	81.5	56. *ap.*	72. *ap.*	72.	....	....
Greatest anteroposterior diameter of mandible measured along one ramus....	445.	No. 21072 404.	....	458.	....	450. *ap.*	415.?

MEASUREMENTS OF SKULL—*Continued*

	E. caballus	E. occidentalis No. 20097 *a* Rancho La Brea	E. occidentalis No. 20098 *b* Rancho La Brea	E. occidentalis No. 19832 *c* Rancho La Brea	No. 20099 *d* Rancho La Brea	E. niobrarensis Type	E. laurentius Type
Anteroposterior diameter of symphysis..............	93.6	77.5		97.3	....	90.	85.
Least width of symphysial region..................	40.	45.3		46.8 *ap.*		....	....
Height of mandible below anterior end of P₂, measured perpendicular to inferior border............	50.	64.8		71.7	....	66. *ap.*	
Height of mandible below anterior end of M₁, measured normal to upper border..................	59.	87.4		95.	....	96. *ap.*	73.?

> *a* Young adult, M³ in function; inner enamel ring of I¹ still present.
> *b* Young adult, M³ slightly worn; inner enamel ring of I¹ still remaining.
> *c* Old individual, molars well worn.
> *d* Young individual, M¹ just emerging.
> *ap.* Approximate.   *l*, left.   *r*, right.

The anterior palatine foramina are situated much as in *E. caballus*. In some specimens they are relatively and absolutely shorter than in the domestic horse. The posterior palatine foramina are situated near the posterior end of M² in animals of middle age, and near the middle or anterior end of M³ in old individuals. The palatine notch of the posterior nares is opposite the anterior half of M² in specimens of young adults, and extends forward approximately to a line joining the middle region of the second upper molars in individuals of advanced age. In *E. caballus* this opening is somewhat shorter and wider, and does not reach as far forward in the palate.

The infraorbital foramina are commonly situated in advance of the anterior end of the maxillary ridges and above P³. In no case do the maxillary ridges extend forward beyond the infraorbital foramina as may occur in some forms of *Equus*.

The mental foramina are approximately opposite the posterior end of the symphysis.

DENTITION

The dentition is represented by a series of specimens ranging from unworn milk teeth to those of old individuals in which the

enamel folds of the fossettes and valleys have disappeared through wear.   Variations in size and in enamel pattern of the cheek-teeth are considerable.   There is, however, such a gradation in the teeth that there seems good reason for considering all of the speci-mens represented as a single species.

The incisors, where observed, are large.   The lower incisors in no. 21000, an old individual, are especially wide.   In none of the
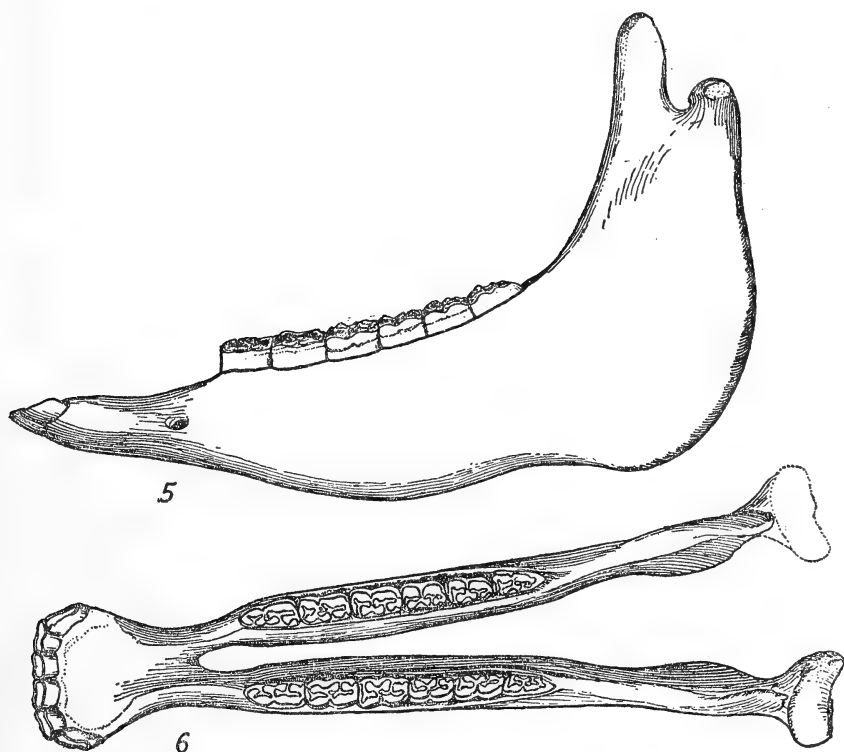
FIGS. 5 AND 6. *Equus occidentalis* Leidy(?).   Mandible, no. 21000, $\times$ $\frac{1}{5}$.   Rancho La Brea Beds, California.   Fig. 5, lateral view; fig. 6, superior view.

specimens available does the third lower incisor show evidence of formation of an inner fold or cup.   The third upper incisor always shows a strongly marked cup.

The canines are of moderate size compared with those of *Equus caballus*.   In young individuals the crown shows distinct lateral compression.

In teeth of corresponding position in the upper cheek-tooth series there is considerable range in size.   In general the variation

falls within the limits which Gidley[3] has shown to hold for modern *Equus caballus*. The variation in width of corresponding teeth between M[2] and P[3] is commonly not more than two millimeters in individuals of approximately the same age. In the lower cheek-teeth there is also considerable variation in size.

As a rule the enamel pattern of the cheek-teeth is relatively simple compared with that of other described forms (figs. 7 and 8). In some specimens there are noticeable variations from the normal type of this species, but in no case is the enamel surrounding the fossettes as strongly folded as in *Equus pacificus*. Some of the principal variations in the pattern of the cheek-teeth are the fol-

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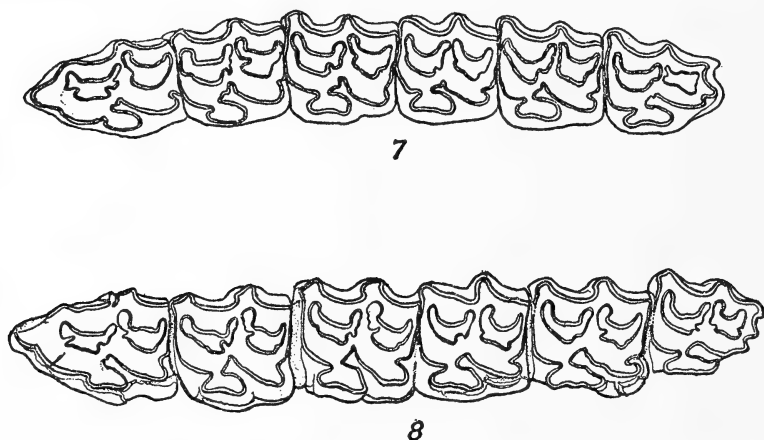
Figs. 7 and 8. *Equus occidentalis* Leidy. Rancho La Brea Beds, California. Fig. 7, superior dentition, no. 21001, × ½; fig. 8, superior dentition, no. 12269, × ½.

lowing: (1) form of protocone; (2) form of post-protoconal valley; (3) position of the post-protoconal valley; (4) plication of the anterior border of prefossette and posterior border of postfossette.

Form and size of protocone vary considerably in the Rancho La Brea specimens. The anteroposterior diameter in M[2] runs from about 11 mm. in an old individual to 16 mm. in a young specimen. In general the protocone seems absolutely longer anteroposteriorly and narrower transversely in young individuals. It is shortest anteroposteriorly and thickest transversely in quite old individuals. Variation in stage of wear is probably in part responsible for the location of the longest protocone in one tooth rather than in another of the same series. The writer does not consider that variation in

[3] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 14, p. 102, 1901.

size or form of the protocone in the Rancho La Brea horses indicates the presence of more than one species.

In most specimens from Rancho La Brea the post-protoconal valley ends anteriorly with an oblique truncation, the truncated face being directed forward and outward. In a number of cases, particularly in young individuals, the enamel bordering the anterior end of the valley shows a single indentation. The fold is usually near the middle of the anterior end of the valley in P^3 and P^4, but is commonly situated near the outer side of the anterior end in M^1 and M^2. In individuals of fairly advanced age the fold is commonly absent. In aged individuals there is rarely a suggestion of the fold.

The position of the post-protoconal valley varies considerably with respect to the region of the tooth margin toward which the long axis of the valley points. In the molars the axis commonly points toward the inner or lingual half of the anterior border of the tooth, in P^3 and P^4 the anterior end is usually directed toward the outer half of the anterior side of the tooth. The position in P^3 and P^4 is referred to as erect, that in the molars as depressed. The difference in position is frequently related in part to difference in form of the protocone.

The anterior and posterior fossettes of the molars and premolars have in general relatively simple enamel borders compared with most Pleistocene horses of North America. There is quite uniformly a single clearly defined fold in the middle of the anterior side of the postfossette and one on the posterior inner region of the prefossette. A few minor wrinkles may also be present near the major folds just mentioned. On the anterior side of the prefossette there is often a single weak fold or indentation. This fold is usually strongest on the premolars and on M^1, though it may be present on the other molars. The anterior fold is generally absent in advanced stages of wear. On an individual with M^3 just coming into function it is absent or barely indicated on M^1 and M^2, but is distinctly shown on the last two premolars. On the posterior fossette a posterior indentation or fold is commonly present in young animals, but may be poorly developed. It is often most distinct on the premolars. Both the anterior fold of the prefossette and the posterior fold of the postfossette may, in rare cases, be accompanied by a few minor wrinkles.

In the upper cheek-teeth the external ribs formed by parastyle,

mesostyle, and metastyle are very strong, but even in old individuals the mesostyle of the molars shows somewhat less flattening externally than in *E. caballus*.
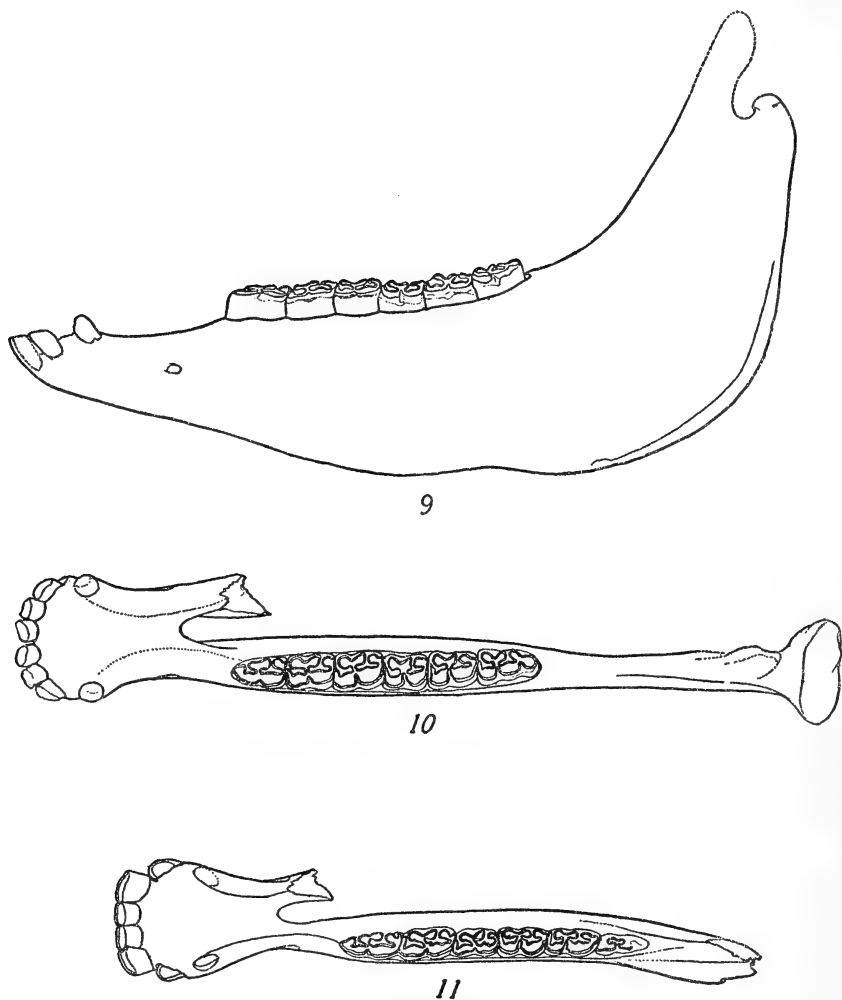
FIGS. 9 AND 10. *Equus occidentalis* Leidy. Mandible with dentition, no. 12269, × ⅕. Rancho La Brea Beds, California. Fig. 9, lateral view; fig. 10, superior view.
FIG. 11. *Equus occidentalis* Leidy. Mandible with dentition, no. 21002, × ⅕. Rancho La Brea Beds, California.

The lower cheek-teeth (figs. 5, 6, 9, 10, 11) do not differ greatly from those of *E. caballus*. Compared with specimens of the domestic horse available, the Rancho La Brea form seems to have relatively

narrower lower premolars, but measurements of other specimens of modern horses seem to indicate that this character may not show a constant difference.   In the premolars the outer enamel fold between the protoconid and hypoconid is not produced between the antero-posterior folds separating the metaconid and metastylid from the protoconid and hypoconid.   In the molars the inner end of the outer fold may extend between the two anteroposterior folds.   Particularly in young specimens there may be a tendency to form a small secondary fold on the posterior side of the outer fold between proto-conid and hypoconid.   In some cases the anterior end of the antero-posterior fold between metastylid and hypoconid may show an indentation (fig. 6), and the enamel wall on the inner side of the
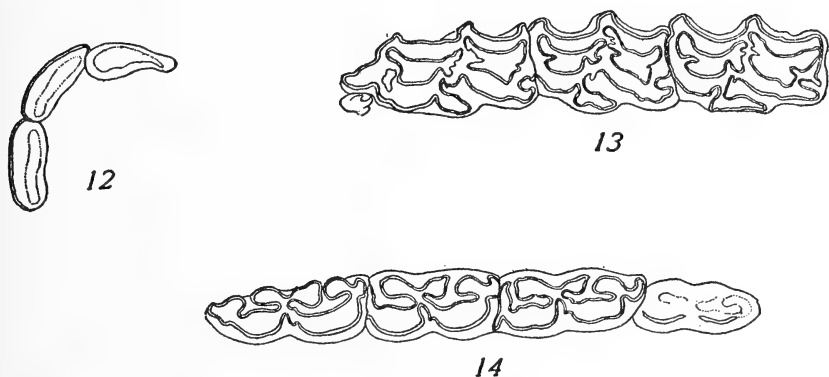
FIGS. 12 AND 13. *Equus occidentalis* Leidy. Superior milk dentition, no. 20099, × ⅛. Rancho La Brea Beds, California. Fig. 12, temporary incisors; fig. 13, temporary molars.
FIG. 14. *Equus occidentalis* Leidy. Inferior temporary molars, no. 21072, × ½. Rancho La Brea Beds, California.

hypoconid may show a slight crinkling. The groove between the metaconid and metastylid columns is well marked but wide. In general the characters of the lower teeth seem close to those of *E. niobrarensis*.

The *milk dentition* is well shown in several specimens. In the upper milk molars (fig. 13), the post-protoconal valley shows a light terminal indentation in specimen 20099, in which M^1 is just pushing through the jaw. In no. 19834, a slightly older specimen, the terminal indentation of the post-protoconal valley has almost disappeared. There is a single indentation at the anterior end of the anterior fossette, and one at the posterior end of the posterior

fossette, in each of the cheek-teeth in both no. 20099 and no. 19834.

In the lower milk molars (fig. 14), the outer fold between the protoconid and hypoconid pushes farther in toward the middle of the tooth than in the permanent premolars. The small fold or jog on the posterior side of this outer fold is well marked. The small fold on the antero-external angle of Dm_4 is well shown.

Measurements of Dentition

Measurements of all cheek-teeth are made *exclusive of the cement.*

In the upper dentition, excepting in P^2 and M^3, the anteroposterior diameter is measured along the middle of each tooth, between the principal anterior and posterior faces of contact with the adjoining teeth. In P^2 and M^3 the anteroposterior diameter is measured from the middle of the face of contact with the adjoining tooth to the extreme opposite limit of the tooth. In P^3 to M^2 the anteroposterior diameter does not include the anterior projection of the parastyle in advance of the principal anterior contact plane of the tooth. Transverse diameters are measured across from mesostyle to the innermost extent of the protocone.

In the lower cheek-teeth the anteroposterior diameter is measured as in the superior series, and includes the limits measured along the middle of the tooth. The transverse diameter of the lower cheek-teeth is the greatest diameter measured across the protoconid and metaconid excepting in P_2. In P_2 the transverse measurement is across hypoconid and entoconid.

Measurements of Permanent Dentition

	E. occidentalis No. 20097 Rancho La Brea	E. occidentalis No. 20098 Rancho La Brea	E. occidentalis No. 12269 Rancho La Brea	E. occidentalis Type specimen	E. pacificus	E. niobrarensis Type specimen	E. excelsus Type specimen	E. scotti No. 10628 A. M. N. H.
Length of upper molar-premolar series	195. mm.	197.	190.	....	....	179.	....	194.
Length of upper premolar series, without P^1	106.5	111.	105.	....	....	98.	....	105.
Length of upper molar series	84.	87.8	85.5	....	....	81.	78.	88.5
P^2, anteroposterior diameter	42.4	44.	41.	....	....	38.	....	43.
P^2, transverse diameter	27.8	26.8	27.4	....	....	27.	....	30.5
P^3, anteroposterior diameter	33.3	34.	31.7	32.	35. t	30.	....	34.
P^3, transverse diameter	29.6	28.7	30.	28.5	32. t	28.	....	33.
P^4, anteroposterior diameter	30.5	33.3	31.8	....	34.5 g	29.	28.5	33.
P^4, transverse diameter	28.1	29.5	31.	....	32.5 g	27.	28.5	33.

MEASUREMENTS OF PERMANENT DENTITION—*Continued*

	E. occidentalis No. 20097 Rancho La Brea	E. occidentalis No. 20098 Rancho La Brea	E. occidentalis No. 12269 Rancho La Brea	E. occidentalis Type specimen	E. pacificus	E. niobrarensis Type specimen	E. excelsus Type specimen	E. scotti No. 10628 A.M.N.H.
M_1, anteroposterior diameter	29.6	29.2	27.5	....	....	27.	26.5	30.
M^1, transverse diameter	27.8	28.6	30.5	....	....	28.	28.5	30.
M^2, anteroposterior diameter	28.	30.8	28.4	31.	32.5 g	26.	26.5	31.
M^2, transverse diameter	25.9	26.5	28.5	27.	31. g	26.	27.	29.
M^3, anteroposterior diameter	25.9	27.	28.8	....	....	26.5	26.	31.
M^3, transverse diameter	21.2	18.6	26.	....	....	24.5	19.	24.
I^1, greatest transverse diameter	20.9	18.7	....	....	....	19.	....	....
I^2, greatest transverse diameter	23.1	23.9	....	....	....	20.	....	....
C, greatest anteroposterior diameter	13.5	15.	....	....	....	....	....	....

t Type specimen.   *g* Gidley's specimen from Fossil Lake, Oregon.

	E. occidentalis No. 19832 Rancho La Brea	E. occidentalis No. 21002 Rancho La Brea	E. occidentalis No. 12269 Rancho La Brea	E. occidentalis No. 21072 Rancho La Brea	E. occidentalis No. 21200 Rancho La Brea	E. niobrarensis Type specimen
Length of lower molar series	85.5 mm.	91.	88.	....	90.	84.
Length of lower premolar series	86.7	100.	95.8	111.7	106.5	94.
P_2, anteroposterior diameter	31.	36.2	34.	40.1	38.5	35.
P_2, transverse diameter	16.	15.7	17.8	14.6	17.4	15.
P_3, anteroposterior diameter	28.	32.	29.8	34.3	33.5	28.
P_3, transverse diameter	14.9	16.4	17.	14.1	20.	16.
P_4, anteroposterior diameter	27.	30.	29.5	37.4	34.5	30.
P_4, transverse diameter	16.7	14.3	18.2	13.	18.3	16.
M_1, anteroposterior diameter	23.2	31.	26.	....	28.5	27.5
M_1, transverse diameter	15.9	16.	17.	....	14.5	14.
M_2, anteroposterior diameter	26.5	32.5	27.	....	30.	27.
M_2, transverse diameter	15.2	15.6	17.3	....	15.7	13.5
M_3, anteroposterior diameter	35.	29.	31.5	....	33.	30.
M_3, transverse diameter	13.8	11.	16.	....	12.4	13.
I_1, greatest transverse diameter	....	....	....	....	18.	17.
I_2, greatest transverse diameter	....	....	....	....	21.8	17.
C, greatest anteroposterior diameter	15.2	....	....	....	....	....

MEASUREMENTS* OF MILK DENTITION

	No. 20099 a	No. 19834 b	No. 21072 c	No. 19835 d
Dm¹, anteroposterior diameter..............	7.5 mm.	....	....	....
Dm², anteroposterior diameter..............	50.	48.	....	....
Dm², transverse diameter..................	24.6	24.8	....	....
Dm³, anteroposterior diameter..............	34.	33.	....	....
Dm³, transverse diameter..................	26.	26.5	....	....
Dm⁴, anteroposterior diameter..............	38.	36.2	....	....
Dm⁴, transverse diameter..................	24.5	26.2	....	....
Di¹, greatest transverse diameter...........	22.9	....	....	....
Di², greatest transverse diameter...........	25.8	....	....	....
Di³, greatest transverse diameter...........	19.	....	....	....
Dm₂, anteroposterior diameter..............	....	....	40.	39.8
Dm₂, transverse diameter..................	....	....	14.2	14.8
Dm₃, anteroposterior diameter..............	....	....	34.	34.9
Dm₃, transverse diameter..................	....	....	14.5	16.2
Dm₄, anteroposterior diameter..............	....	....	37.2	34.6
Dm₄, transverse diameter..................	....	....	12.9	15.9
Di₁, greatest transverse diameter...........	....	....	....	17.8
Di₂, greatest transverse diameter...........	....	....	....	18.3
Di₃, greatest transverse diameter...........	....	....	....	14.5

* Measurements taken in manner indicated in discussion on page 840.

a, M¹ just emerging through jaw.

b, M¹ erupting.

c, M₁ showing first traces of wear.

d, M₁ in function, M₂ erupting.

COMPARISON WITH EQUUS CABALLUS

The skulls of Rancho La Brea horses have approximately the size seen in the modern domesticated horse, but range upward to dimensions greater than those of the average domesticated horse. They differ from *Equus caballus* in the shorter and wider nose, more convex forehead, narrower occiput, and more massive lower jaw. The mandible is very noticeably higher below the premolars and the diastema.

The dentition of the Rancho La Brea species differs from that of *Equus caballus* in the more simple pattern of the enamel of the cheek-teeth. The dimensions do not differ markedly.

RELATIONSHIP TO PLEISTOCENE SPECIES OF WESTERN NORTH AMERICA

In comparing the Rancho La Brea horses with the known Pleistocene species of America considerable difficulty is encountered, as the larger number of described forms are based upon very scanty material, usually cheek-teeth alone. Only three North American

Pleistocene horses are known by skulls, and of these only *Equus scotti* is represented by more than one specimen. Of *Equus laurentius* there is one good skull, of typical *Equus niobrarensis* one specimen with imperfect facial and frontal region. It is probable that several of the American species of *Equus* which are considered distinct run near each other in skull characters, and until the approximate limits of variation are known in each, it will be difficult to make certain of specific distinctions.

Until the appearance of the important papers by Gidley[4] on *Equus scotti*, and Hay[5] on *Equus laurentius* and *Equus niobrarensis*, specific separation of American Pleistocene horses was based almost entirely upon characters of the cheek-teeth, and in a considerable number of species but little material was known. As has been shown by Gidley, horse teeth of the same stage of growth may vary markedly in size and pattern, and where various stages of wear are compared the range of difference is wide. As first noted by Gidley, the character of size, particularly as seen in the transverse diameter, of the cheek-teeth seems the most reliable.

While it is doubtless true that good specific differences appear in the enamel pattern of the cheek-teeth, it is certain that such characters must be used with caution. The final determination of the value of these characters must depend upon examination of considerable series of individuals of nearly the same age.

Relation to Equus occidentalis Leidy.—Typical horses of the genus *Equus* have been known fossil from California in two species represented by very fragmentary remains. The first form described, *Equus occidentalis* Leidy,[6] was based upon a specimen found in Pleistocene auriferous gravels at a depth of thirty feet below the surface in Tuolumne County, California. Better material from an asphalt bed near Buena Vista Lake in the southern end of the Great Valley of California was afterward referred to this species by Leidy.[7] The second species, *Equus pacificus* Leidy,[8] was based upon an upper premolar tooth from Martinez, California. Gidley[9] recognizes this species as the common horse of the Pleistocene at Fossil

[4] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 13, art. 13, 1900.

[5] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44 (no. 1969), 1913.

[6] Leidy, J., Proc. Acad. Nat. Sc. Philad., 1865, p. 94.

[7] Leidy, J., Extinct Mammalia of Dakota and Nebraska, p. 267, 1869. Also Geol. Surv. Terrs., vol. 1, p. 242, pl. 33, fig. 1, 1873.

[8] Leidy, J., Proc. Acad. Nat. Sc. Philad., 1868, p. 195.

[9] Gidley, J. W., Bull. Am. Mus. Nat. Hist., vol. 14, p. 116, 1901.

Lake, Oregon. These two species have come to be well known in palaeontologic literature as representing the Pacific Coast horses, though relatively meagre information has been available concerning both forms.

The cheek-teeth from Tuolumne County, California, constituting Leidy's type of *Equus occidentalis* agree very closely in dimension and in enamel pattern with average specimens from Rancho La Brea. Considering that the typical *Equus occidentalis* occurs in approximately the same geographic region as the asphalt forms, there seems every reason to believe that the common horses from Rancho La Brea represent *Equus occidentalis*. The material from near Buena Vista Lake in the southern end of the Great Valley of California, which Leidy referred to *Equus occidentalis*, seems quite certainly to represent the same species as the specimens from Rancho La Brea.

In the table of measurements on p. 840, the dimensions of Rancho La Brea specimens are shown in comparison with those of the type of *Equus occidentalis*.

Comparison with Equus pacificus Leidy.—The relation of the Rancho La Brea horses to the type described from Martinez, California under the name of *Equus pacificus* is not so easily determined as is their affinity to *E. occidentalis*. The type of *E. pacificus* as described by Leidy consisted of a single upper premolar three, which was not figured. The enamel is described as less simple than in the horses of the group referred to *E. occidentalis* of California, and there was stated to be an inflection of the enamel at the anterior end of the post-protoconal valley. The tooth was characterized especially by its large size. The dimensions are compared with those of *E. occidentalis* in the table on p. 840. As is seen in the table of measurements, the largest specimens from Rancho La Brea approach the type of *E. pacificus* in dimensions. They are, however, quite different in average pattern of the enamel. Even the largest specimens from Rancho La Brea fall below the dimensions of Leidy's type of *E. pacificus*, and below Gidley's typical material from Fossil Lake. It is very doubtful whether any of the Rancho La Brea specimens thus far examined can be referred to *E. pacificus*. It is evident that the typical horses of Rancho La Brea are *E. occidentalis*.

Comparison with Equus excelsus Leidy.—The Great Plains species described as *Equus excelsus* by Leidy in 1858, from material ob-

tained in Nebraska, approaches the California *E. occidentalis* very closely. In reviewing the species in 1869 Leidy[10] stated that there was little doubt that *E. excelsus* and *E. occidentalis* were the same, and he united the two. In 1873 Leidy[11] referred to the two under the name of *E. occidentalis*. As pointed out by Gidley[12] the name *E. excelsus* really precedes *E. occidentalis*. Gidley suggests that the Nebraska form shows a tendency to more complicated enamel pattern of the cheek-teeth, and that it may be a relatively simple variation of a form normally with a much more complicated pattern than the typically simple teeth of the California *E. occidentalis*. Gidley also calls attention to the fact that *E. excelsus* and *E. occidentalis* were described from geographic stations widely separated on opposite sides of the Rocky Mountain system. After weighing the evidence available, Gidley held it wisest to consider the two species as distinct.

Recently Hay[13] has referred to *E. excelsus* additional material, and has discussed the relation of the species to *E. niobrarensis*.

With only meagre material representing the cheek-tooth dentition at hand, it seems futile to attempt to establish definitely the relationship of *E. excelsus* to the California *E. occidentalis*. It is certainly necessary to have a larger series of teeth, and it will probably be necessary to have good skull material before a satisfactory comparison can be made.

A character of the type of *E. excelsus* to which both Gidley and Hay have called attention is the position of the postpalatine foramina, which are unusually far forward, opposite the anterior half of M^2. In the Rancho La Brea skulls the postpalatine foramina range from a position opposite the middle of M^3 in individuals of advanced age to a position opposite the posterior half of M^2 in individuals of middle age with all of the molars in function. The type of *E. excelsus* represents a young adult with M^3 sufficiently worn to show the enamel pattern clearly. It is possible that the somewhat advanced position in the California form may be indicative of relationship to *E. excelsus*.

Comparison with Equus scotti Gidley.—Of the American Pleistocene horses known up to the present time *Equus scotti*, described

[10] Leidy, J., Extinct Mammalian Fauna of Dakota and Nebraska, p. 267, 1869.

[11] Leidy, J., Geol. Surv. Terrs., vol. 1, p. 243, 1873.

[12] Gidley, J. W., Bull. Am. Mus. Nat. Hist., vol. 14, p. 115, 1901.

[13] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44 (no. 1969), p. 592, 1913.

by Gidley,[14] is the only form represented by more than a single skull. Unfortunately only one of several skulls obtained up to the time of Gidley's revision of the Pleistocene horses in 1901 was that of an adult in which all of the teeth had come into full use. The Rancho La Brea horses resemble *E. scotti* in being a large-headed form. They differ from *E. scotti* in the somewhat smaller cheek-teeth, less pronounced enamel folds around the fossettes and at the anterior end of the post-protoconal valley of the cheek-teeth, and possibly also in possessing a shorter and wider nose. Other differences will doubtless appear when the two species can be more fully compared.

Comparison with Equus niobrarensis Hay.—Hay's recently de-scribed species, *Equus niobrarensis,*[15] from Hay Springs, Nebraska, approaches the Rancho La Brea form closely in characters of skull and dentition. Both types have a heavy, short head, a heavy mandible, and a short, wide nose. The Rancho La Brea species differs slightly from *E. niobrarensis* in the shortness and width of nose, relative narrowness across the skull through the anterior region of the maxillary ridges, relative narrowness in superior view immediately in front of the inion, and smaller size of the orbits. The postpalatine foramina and the anterior end of the inferior nasal opening are somewhat farther forward in some specimens than in *E. niobrarensis.*

The cheek-teeth of the Rancho La Brea form are slightly larger than in *E. niobrarensis,* and the tooth row is in most specimens relatively longer. The relation of the tooth row to the basilar length in the type of *E. niobrarensis* is 33.8%. In no. 21002, a much older specimen, from Rancho La Brea, the proportion is 34.9%. In no. 20098 it is 36%.

As shown in the table of measurements on page 840, the average width of the cheek-teeth of the Great Plains form is somewhat less than in the average of the Rancho La Brea specimens. Unless the difference can be shown to hold for a large number of individuals it would hardly be considered of specific value. Between *E. nio-brarensis* and the Rancho La Brea form there are certain small differences in the pattern of the enamel. In *E. niobrarensis* the folding of the enamel at the anterior and posterior borders of the

[14] Gidley, J. W., Bull. Am. Mus. Nat. Hist., vol. 13, p. 111, 1900.
[15] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44 (no. 1969), p. 576, 1913.

fossettes, and at the anterior end of the post-protoconal valley is more pronounced, and in that species the anterior end of the post-protoconal valley is wider.

The relation of *E. niobrarensis* to the Rancho La Brea horses suggests a resemblance of the former species to *E. excelsus*. *E. excelsus* is apparently somewhat nearer to *E. niobrarensis* than is the California *E. occidentalis*. In a recent paper Hay[16] has discussed the relationships of *E. niobrarensis* and *E. excelsus*, and considers them distinct. In Hay's paper a series of cheek-teeth referred to *E. excelsus* seems partly to bridge the gap between these two species, but other characters may still separate them.

The California *E. occidentalis* appears to be separable from *E. niobrarensis* by more simple pattern of the enamel of the cheek-teeth, and by several skull characters, no one of which seems, however, entirely reliable with the material available. The presumption is that these species are distinct, but it is very desirable to have more material of *E. niobrarensis* for a fully satisfactory comparison.

Comparison with Equus laurentius Hay.—A fine skull from supposed Pleistocene near Lawrence, Kansas, recently described by Hay,[17] and designated as the type of a new species, *Equus laurentius*, represents a form quite different from the California *E. occidentalis*. The skull and teeth in *E. laurentius* are much smaller; the nose is relatively longer and narrower; the width behind the orbits is relatively greater; the mandible is much more slender, being narrower or lower below the premolars; the inferior border of the mandible is straight instead of sinuous as in *E. occidentalis*; the orbits seem to be relatively larger.

SUMMARY

The species of horse commonly represented in the Pleistocene beds of Rancho La Brea is not separable from *Equus occidentalis* first described by Leidy from Tuolumne County, California.

As represented by the excellent series of specimens from Rancho La Brea, *Equus occidentalis* is characterized by its large, heavy head, short and broad nose, high and heavy mandible, and relatively simple enamel pattern of the cheek-teeth.

[16] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44 (no. 1969), p. 592, 1913.
[17] Hay, O. P., Proc. U. S. Nat. Mus., vol. 44 (no. 1969), p. 584, 1913.

Transmitted September 18, 1913

ASPHALT BEDS OF RANCHO LA BREA

SINCE 1906, the University of California has been continuously engaged in a study of the prehistoric life of California represented to us in a marvelous collection of fossil remains, buried in the asphalt deposits of Rancho La Brea near Los Angeles. The great quantity of material found, the wonderful preservation of the specimens, and the great variety of life represented all serve to make this locality scientifically one of the peculiar natural features of this state. The results which are coming out of a study of the collections are the most important ever obtained in this field of study on the Pacific Coast.

The bone deposits of Rancho La Brea are found in asphalt pits or chimneys which are the vents through which oil and gas have escaped from great reservoirs located far below the surface. Since the first accumulation of the asphalt there has been continual trapping of animals coming in contact with the sticky pools. Wherever oil is exuded at the present time, we find birds, gophers, squirrels, dogs, and even cattle frequently entangled. This process has led to the heaping up of great quantities of remains of animals in past periods. In many of the pits the bones are found massed and matted together in enormous numbers. Literally hundreds of thousands of specimens have been obtained from these deposits.

The representation of ancient life at Rancho La Brea includes numerous kinds of animals, the total number amounting to considerably more than one hundred forms. These include species of elephant, camel, and horse, a saber-toothed tiger, a giant cat closely related to the existing lion, and great numbers of extinct wolves. The bones are all perfectly preserved as though buried within the past few years, and can be assembled in complete skeletons which may be multiplied to hundreds in the University collections.

In the course of work at Rancho La Brea, many of the advanced students have taken part in the excavations and in the scientific study of the collections.

NOTE ON THE SYSTEMATIC POSITION OF THE WOLVES OF THE CANIS DIRUS GROUP

IN A STUDY of the Pleistocene canid fauna of Rancho La Brea the writer had occasion some years ago to consider division of the wolf group into several subgenera. The principal evidence favoring splitting of the group was found in the wide difference between the dire wolf, *Canis dirus*, and all other representatives of the Canidae in North America. The only circumstance which prevented setting the wolves of the *C. dirus* group aside as a distinct genus or subgenus was the lack of such differentiation within this group as is to be expected in a generic division showing as wide a geographic range as that of the *C. dirus* forms. The suggestion was made that differentiation comparable to that characteristic of a genus was perhaps offered by the presence in the Rancho La Brea fauna of a second species of the *C. dirus* group, namely *Canis milleri*. The *milleri* form was described as a distinct species having characters approximating more closely to those of *C. dirus* than to the characters of the timber wolves of the *C. occidentalis* group.

Subdivision of the *Canis* group of America has already been proposed by other authors who would separate such distinct groups as the timber wolves and coyotes. Regardless of the question as to generic or subgeneric rank of these divisions, there seems to the writer no question concerning the necessity of this grouping in order to express the relationships and history of these forms.

The writer's view concerning the generic distinction of the wolves of the *C. dirus* group has received substantial confirmation through the discovery of new material representing a wolf related to *C. dirus* in the Pleistocene of Florida. In his important paper on "Human Remains and Associated Fossils from the Pleistocene of Florida" Dr. E. H. Sellards[1] has described the first skull of a member of the dire wolf group found outside the California region.

[1] Sellards, E. H., 8th Ann. Rep. Florida Geol. Surv., pp. 152–57, pls. 24, 30, figs. 1, 3, 1916.

The dentition of Dr. Sellards' specimen very closely resembles that of the type specimen of *C. dirus* from Indiana. These characters also fall well within the range of variation of the dire wolves of Rancho La Brea. The greater number of the unusual characters distinguishing the wolves of the *dirus* group are recognized by Dr. Sellards in his specimen from Vero. The Florida skull is, however, characterized by quite different proportions of the facial region, the nose and the palate being much narrower and more slender, and the premolar teeth more widely spaced than in the Rancho La Brea group. In view of these differences, Dr. Sellards seemed justified in separating the Florida wolf as a new species to which he has given the name *Canis ayersi*.

Considering that the several types included in the *dirus* group represent at least three quite distinct forms, in all of which there appears a group of common characters sharply distinguished from those of other wolves, there is ample justification for distinguishing this group as a separate genus or subgenus for which the name *Aenocyon*[2] may be applied.

The generic characters of *Aenocyon* are found in the massiveness of skull and dentition, extreme overhang of the inion, shortness of the basicranial region posterior to the glenoid fossae, massiveness of the upper and lower carnassials, reduction of the hypocone of $M\underline{1}$, and probably in characters of the skeleton not as yet available from other material than that obtained at Rancho La Brea.

The genus *Aenocyon* was widely distributed over North America in Pleistocene time. Its range extended from the east to the west coast and from Mexico at least as far north as the upper portion of the Mississippi Valley. Whether its geographic range extended into the Canadian area is as yet uncertain. It is possible that the timber wolves of the *Canis occidentalis* group occupied the northern portion of the continent contemporaneously with the maximum development of the *Aenocyon* group in the Sonoran region. The geologic range of *Aenocyon* is also still to be determined. A somewhat puzzling feature in the distribution of these wolves is found in their absence from the Pleistocene of Fossil Lake, Oregon. The Fossil Lake deposits contain a large vertebrate fauna representing a wide variety of forms and ranging from the largest to the smallest mammals and

[2] Aenos: terrible, dreadful; cyon: wolf.

birds, and including representation of some of the most delicate osseous structures.   Wolf remains are well known in this fauna, including bones of both timber wolves and coyotes, but as yet no representation of *Aenocyon* has been recognized in the collections from this locality.   Had *Aenocyon dirus* or any other member of the group been present in this region in numbers comparable to those known elsewhere in the Pleistocene it would presumably have left at least some trace of its presence.   Its absence may be due to limited northern range, or to deposition of the Fossil Lake beds at a period earlier, or perhaps later, than that of Rancho La Brea and of other deposits in which specimens representative of *Aenocyon* have been found.

The recognized species of *Aenocyon* are *A. dirus*, *A. milleri*, and *A. ayersi*.

Aenocyon dirus[3] (Leidy) is represented in the Rancho La Brea fauna by a wide variety of forms, but always characterized by large size, massiveness of dentition, relatively great width of palate, and of facial region.

Aenocyon ayersi[4] (Sellards) is characterized by large size, relative narrowness of facial region compared with *A. dirus*, massiveness of dentition, and relatively wide spacing of the premolars.

Aenocyon milleri[5] (Merriam) is distinguished in comparison with *A. dirus* and *A. ayersi* by smaller size, relatively low sagittal crest, and less prominent inion.   The dentition is massive as in the other two forms and the premolars are closely set, as is rather common in *A. dirus*.

[3] See Merriam, J. C., The Fauna of Rancho La Brea.   Part II, Canidae, Mem. Univ. Calif., vol. 1, no. 2, pp. 218–246, 1912.
[4] See Sellards, E. H., *op. cit.*
[5] See Merriam, J. C., *op. cit*

NEW PUMA-LIKE CAT FROM RANCHO LA BREA

INCLUDED in a considerable variety of representatives of the *Felis* group known from Rancho La Brea, there is a large puma-like cat representing a species distinct from any thus far described from North America. As the description of this species is necessary to certain studies on the Felidae now in progress, it is desirable to present a preliminary description at this time.

FELIS DAGGETTI, n. sp.

Type specimen, a mandible, no. 21572 from locality 2050, Rancho La Brea, California.

The mandible and dentition have approximately the dimensions found in the Recent puma of California, but are distinguished by unusual massiveness of the cheek-teeth and of the jaw, by unusual
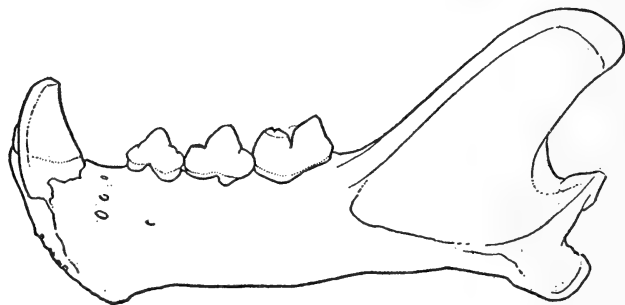
Fig. 1. *Felis daggetti*, n. sp. Outer view of mandible of the type specimen, no 21572, $\times \frac{1}{2}$. From the Pleistocene of Rancho La Brea, California.

width of the angle of the mandible, and by the unusual backward curve or sweep of the coronoid process compared with that in Recent pumas.

This species is named in honor of my friend and colleague, Mr. Frank S. Daggett, Director of the Museum of History, Science and Art, of Los Angeles, whose interest and co-operation in study of the

Rancho La Brea collections have contributed largely to the effectiveness of monographic studies on this fauna now in progress.

The *Felis daggetti* specimens represent an animal equaling or perhaps exceeding in size the largest pumas of the present day. They are apparently to be classed with the puma group rather than with the jaguars, and differ widely from the great cats of the *Felis atrox* type, with which they were associated. The lower jaw represented in the type specimen differs from that of the pumas of the *Felis concolor* type in relatively large size and massiveness of the cheek-teeth, in the extreme width of the posterior region of P$\overline{3}$ and P$\overline{4}$, and in the stronger backward curvature of the long coronoid process. From the jaguar specimens available for comparison the type specimen differs in the more massive lower cheek-teeth, in the greater width of P$\overline{3}$ and P$\overline{4}$, in the relatively shorter anteroposterior diameter of P$\overline{4}$, and to some extent in the greater degree of backward curvature of the coronoid process.
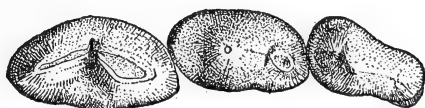
Fig. 2. *Felis daggetti*, n. sp.   Dentition, occlusal view, type specimen, no. 21572, natural size, from the Pleistocene of Rancho La Brea, California.

Several mandible specimens from Rancho La Brea show the characters of the type specimen of *F. daggetti*.   Among these is the posterior portion of a lower jaw representing the first puma-like form recognized in the Rancho La Brea fauna.[1]

MEASUREMENTS OF No. 21572, TYPE SPECIMEN

Greatest length of mandible from anterior end of symphysis to middle
  of posterior end of condyle..................................... 145.7 mm.
Height of mandible below anterior end of M$\overline{1}$...................... 31.5
Height of mandible below anterior end of P$\overline{4}$....................... 27.6
Thickness of mandible below posterior end of M$\overline{1}$.................. 16.3
Height from lower side of angle to upper side of condyle............ 31
Anterior side of canine alveolus to posterior end of M$\overline{1}$.............. 79.5
Length of diastema between posterior side of canine alveolus and an-
  terior side of P$\overline{3}$... 10.5
I$\overline{2}$, greatest transverse diameter................................... 3.1

[1] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, pp. 42 and 45, 1912.

C, anteroposterior diameter of alveolus.............................. 16.9 mm.
P$\overline{3}$, anteroposterior diameter...................................... 14.7
P$\overline{3}$, transverse diameter.. 9.1
P$\overline{4}$, anteroposterior diameter...................................... 17.6
P$\overline{4}$, transverse diameter.. 10.5
M$\overline{1}$, anteroposterior diameter...................................... 21
M$\overline{1}$, greatest transverse diameter................................. 10.8
M$\overline{1}$, transverse diameter across paraconid......................... 10.6
M$\overline{1}$, anteroposterior diameter of protoconid........................ 9.5
M$\overline{1}$, anteroposterior diameter of paraconid 10.6

NOTES ON PECCARY REMAINS FROM RANCHO LA BREA

CONTENTS

INTRODUCTION

STUDY of the collections of Pleistocene mammals obtained by the University of California from the asphalt deposits of Rancho La Brea has revealed a single astragalus belonging to a peccary. Later excavations at Rancho La Brea conducted by the Los Angeles Museum of History, Science and Art under the direction of the late Dr. Frank S. Daggett have brought to light additional remains of the dicotyline group of mammals, among which are a fairly preserved skull and some incomplete limb elements. These are now in the palaeontological collections of the Los Angeles Museum and afford a better opportunity than does the single astragalus to secure needed information concerning the group in the Pleistocene of California.

Infrequency of occurrence of peccaries in the asphalt beds lends special interest to the record of their presence, and may be of greater or less significance in an interpretation of problems relating to the Rancho La Brea fauna. The completeness of the record of Pleistocene mammalian life in western North America as offered by the collections from Rancho La Brea makes it desirable to ascertain the status of the more uncommon types occurring in the asphalt beds, particularly of forms closely related to species met with in other Pleistocene deposits.

PLATYGONUS, possibly n. sp. or n. subsp.

Skull

The skull, no. 4400, L. A. M. H. S. A.,[1] from Rancho La Brea possesses the facial region including the palate and superior dentition. The posterior portion of the specimen has suffered much loss, but on the left side there remain structures around the orbit and posterior to the glenoid fossa that furnish some information of this region of the cranium. At the anterior end of the snout the nasals are broken away. The teeth, with exception of M1 and M2, show a moderate degree of wear. M2 and particularly M1 are well worn, as is also the anterior edge of the superior canine.

Specimen 4400 is definitely referable to the genus *Platygonus*. The diastema between superior canine and P2 is not characterized by great length as in *Mylohyus*, but is slightly longer than in *Tayassu*. It reaches a length slightly greater than that of the premolar series. Two incisors are present in each premaxillary, their alveoli indicating that the forward or medial incisor was very large while the posterior or lateral tooth, situated immediately behind the former, was much smaller. P4 is not molariform. Although the cheek-tooth series has been subjected to attrition, the cusps of the individual teeth seem to be characterized by a more prominent development than in teeth of *Tayassu*.

The specimen available from Rancho La Brea agrees fairly closely in size with peccary skulls from the Pleistocene of Kansas described by Williston[2] under the species *Platygonus leptorhinus*. It likewise compares favorably in this character with skull specimens referred to *P. compressus*. In no. 4400 a shallow fossa is present above and behind the posterior margin of the exit of the infra-orbital canal, while a deeper fossa is located in front of the opening. Fossae comparable to these are noted by Williston in a female skull of *P. leptorhinus*, but are lacking, according to Wagner,[3] in the skull of *P. compressus* from the Pleistocene of Michigan. While the groove or sulcus that extends along the lateral side of the snout is present in the California skull, a continuation of the groove can not be

[1] Los Angeles Museum of History, Science and Art, Los Angeles, Calif.

[2] Williston, S. W., Restoration of Platygonus. Kansas Univ. Quar., vol. 3, pp. 23–39, pls. 7 and 8, 1894.

[3] Wagner, G., Observations on Platygonus compressus Le Conte. Jour. Geol., vol. 11, pp. 777–782, figs. 1–4, 1903.
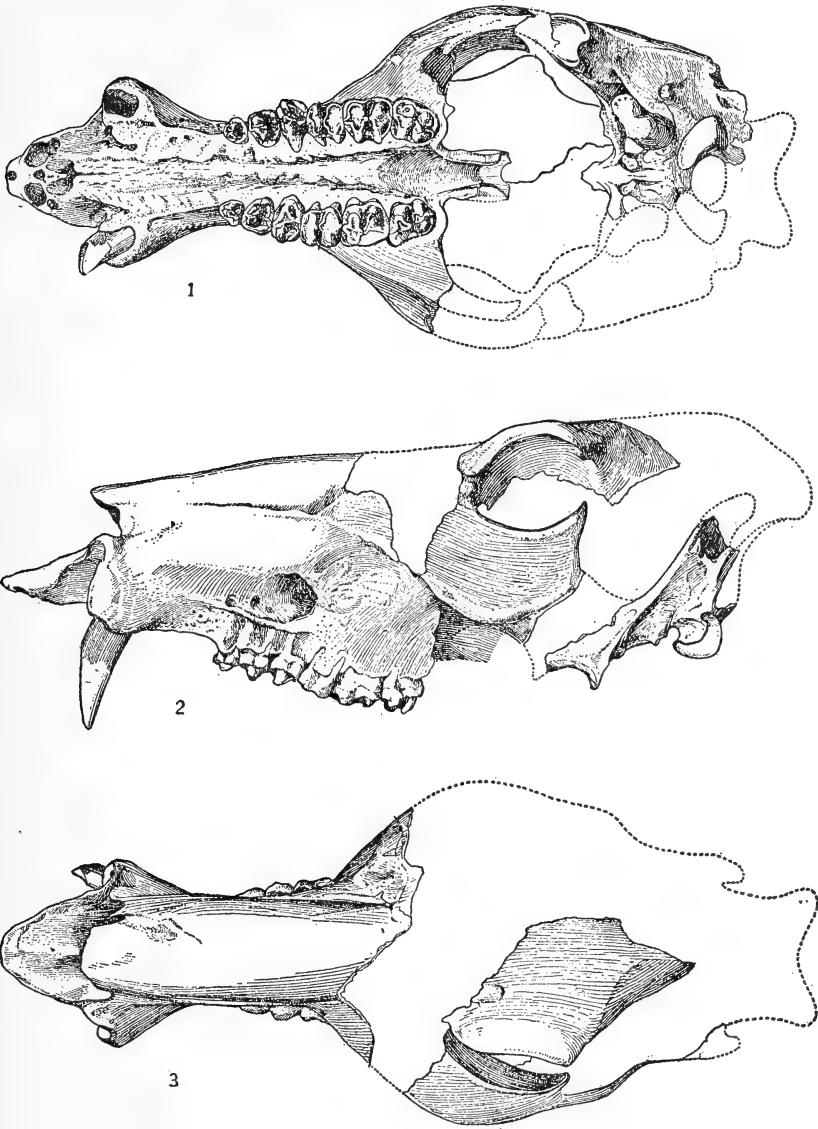
FIGS. 1, 2, AND 3. *Platygonus*, possibly n. sp. or n. subsp. Skull, no. 4400, L. A. Mus. Hist. Sci. and Art Coll. × ⅓. Fig. 1, lateral view; fig. 2, ventral view; fig. 3, dorsal view. Rancho La Brea beds.

traced to the top of the skull because of the destruction of the greater portion of the dorsal surface.   A scar on the preserved part of the frontal suggests the end of the groove of the left side.   If this does represent the dorsal termination, the latter is situated somewhat

closer to the rim of the orbit than in *P. leptorhinus* or in *P. compressus*. Judging from the small portion of the parietal that remains, the dorsal margin of the temporal fossa was apparently not prominent in the specimen from Rancho La Brea. The depth of the malar below the orbit in the skull from the asphalt deposits is exceeded by the corresponding measurement in a single skull of the Kansas series. It is deeper than in the specimens from Rochester, New York, determined by Leidy[4] as belonging to *P. compressus*. The malar is only slightly deeper in no. 4400 than in the Michigan specimen of *P. compressus*.

The Rancho La Brea species, in shortened diastema, approximates more closely the modern peccaries than do other forms of *Platygonus* from the Pleistocene of North America. In no. 4400, however, the diastema between the canine and the cheek teeth is distinctly longer than in *Tayassu*, and the length of the diastema approximates closely that of the upper premolar series. The diastema in the specimen from Rancho La Brea is much shorter than in the skull from Kentucky referred by Leidy[5] to *P. compressus* and in the Pleistocene peccary skulls from Rochester, New York. It is also shorter than in specimens referred to *P. leptorhinus* by Williston, and is distinctly shorter than in the skull of *P. compressus* described by Wagner. In skulls described by Leidy and by Williston the canine tuberosity seems always to extend farther dorsally along the side of the snout than in *Platygonus* from Rancho La Brea. The height of the canine tuberosity is not so great in no. 4400 as in the specimen from Michigan, while in both skulls the height equals the length of the post-canine hiatus.

Between the alveoli for the medial incisors a canal extends forward from the anterior palatine foramen. The palate in the specimen from the asphalt beds is not so broad as that of *P. alemani* from the Pleistocene of Mexico. The median portion of the palate behind M$\underline{2}$ reaches upward to the postnarial notch, the angle which this slope makes with the plane of the palate being greater than in *Tayassu*. The anterior tuberosities of the basioccipital are separated in median line by a wider groove than in *P. leptorhinus*, and the lateral arm of the basisphenoid, which joins with the alisphenoid, lies more in advance of the contact between basioccipital and

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[4] Leidy, J., On Platygonus, an extinct genus allied to the peccaries. Trans. Wagner Free Inst. Sci., vol. 2, pp. 41–50, pl. 8, fig. 1, 1889.

[5] Leidy, J., Trans. Amer. Philos. Soc., vol. 10, pp. 330–341, pls. 36 and 37, 1853.

basisphenoid than in the Kansas form. The comparisons of basioccipital and basisphenoid have been made, however, with only a single specimen of *P. leptorhinus* in the collections of the University of California.

Dentition

The shape of the superior premolar teeth, subject to some variation in *P. compressus*, does not seem to offer a suitable character for diagnostic purposes. In the more fundamental characters relating to structures of the tooth crown, the teeth in the Rancho La Brea skull resemble closely those of *P. leptorhinus* and of *P. compressus*. The superior premolar-molar series in no. 4400 from Rancho La
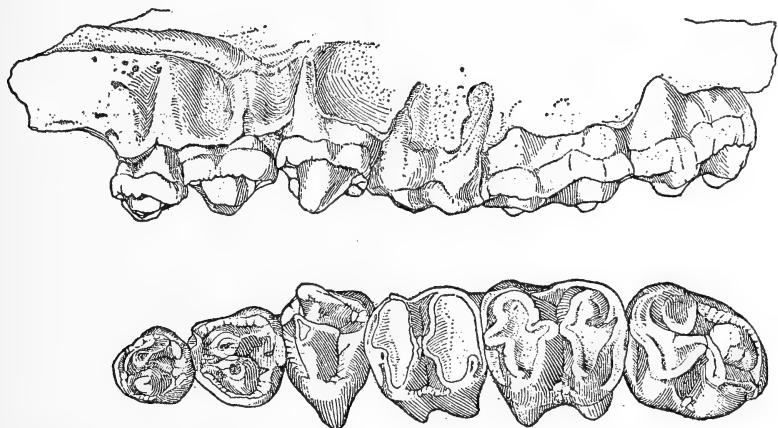
FIG. 4. *Platygonus*, possibly n. sp. or n. subsp. Superior cheek-tooth series, no. 4400, L. A. Mus. Hist. Sci. and Art Coll.   × 1. Lateral and occlusal views. Rancho La Brea beds.

Brea is longer than in specimens of *P. compressus* and *P. leptorhinus*, although this difference is slight.   The cheek teeth approximate very closely in length the upper series of *P. alemani* from Mexico.   The first and second molars in the California specimen are slightly larger than in the Kansas skulls, while measurements of M$\underline{3}$ may be exceeded by those in the latter.   P$\underline{4}$ is slightly larger than the corresponding tooth in the Kansas specimen.   All the teeth in the California skull are smaller than those of *Platygonus vetus* when comparison is made with the measurements given by Williston. With the exception of the anteroposterior diameter of M$\underline{3}$, the teeth are slightly larger than in *P. compressus* from Kentucky.[6]

[6] Leidy, J., *op. cit.*, 1853.

P2 is subtriangular in horizontal section with the anterior side subacute, thus differing slightly from Leidy's specimens from Ken-
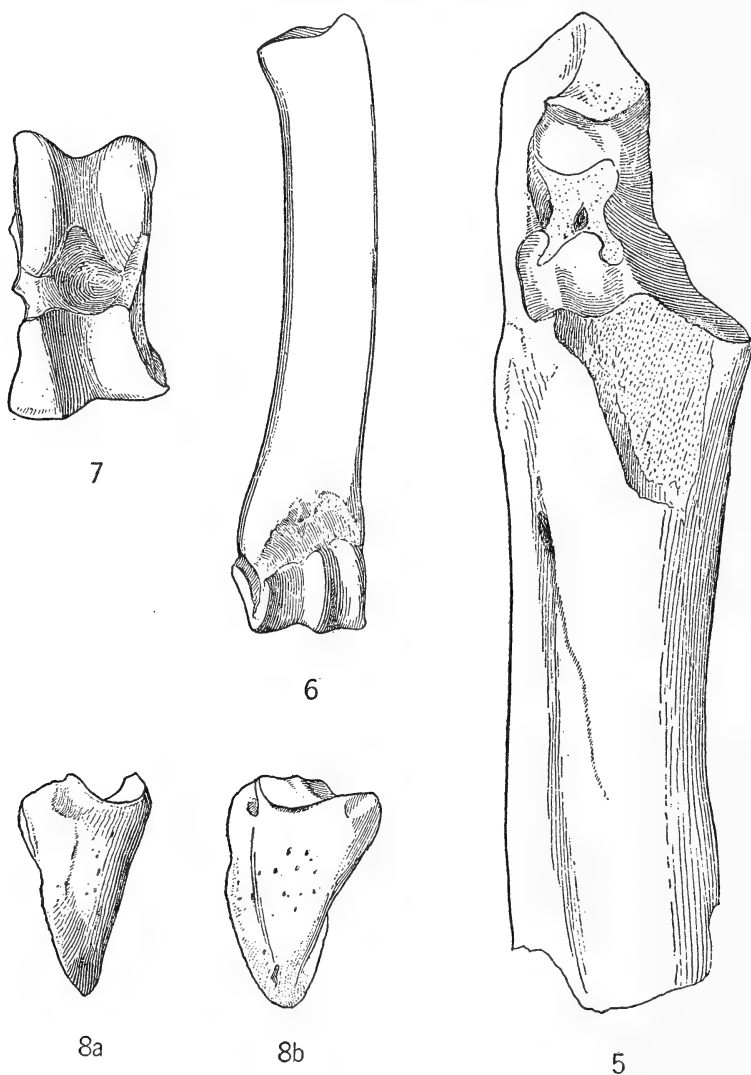
FIGS. 5 TO 8b. *Platygonus,* possibly n. sp. or n. subsp. Limb elements. × 1. Fig. 5, proximal portion of radius-ulna, no. 4402, anterior view; fig. 6, fourth metacarpal, no. 4403, anterior view; fig. 7, astragalus, no. 24066, dorsal view; figs. 8a and 8b, ungual phalanx, no. 4401, lateral and dorsal views. Nos. 4401, 4402, and 4403 in L. A. Mus. Hist. Sci. and Art Coll.; no. 24066 in Univ. Calif. Palae. Coll. Rancho La Brea beds.

tucky. Two cusps are developed on the crown, the inner one of which is somewhat the larger. A well defined cingulum is present,

which is especially prominent on the postero-external side and is absent only at the base of the inner cusp.

P3 is subquadrate with two cusps of nearly equal size.   An incipient tubercle is present immediately behind the space between the two cusps.   A cingulum is strongly developed around the entire tooth.

P4 is shaped much as in *P. compressus*.   Two nearly equal cusps are present on the crown with a tubercle, behind their interspace, slightly stronger than on the crown of P3.   This tooth is little worn. The structure of the crown of the tooth closely resembles that in *P. compressus* and in *P. leptorhinus*.

M1 is much worn.   No cingulum is present on the inner side of both protocone and hypocone, and this is true also for the two posterior molars.   In M2 a well developed cingulum is present along the anterior border.   This ledge is more prominently formed along the posterior base of the hypocone than in the corresponding tooth of *P. leptorhinus*.

In M3 the anterior pair of cusps is larger than the posterior pair and the anterior transverse ridge is wider transversely than the posterior one.   A cingulum is strongly developed along the anterior border and and along the outer posterior border from the paracone to the hypocone.

MEASUREMENTS OF SKULL

Length measured from anterior end of premaxillary to anterior margin of foramen magnum	*a*255 mm.
Length of palate	181
Length of anterior end of canine tuberosity to posterior margin of infra-orbital fossa	84
Vertical height from palate to top of skull, measured at posterior margin of infra-orbital fossa	82.7
Vertical height from palate between canines to top of nasals	50.5
Width across glenoid fossae	*a*128
Width across postorbital processes	*a*88
Width at middle of zygomatic arches	*a*124
Width of face at posterior margins of infra-orbital fossae	46
Width of snout above M2	44
Width between outer walls of canine alveoli	73
Width of palate measured between postero-internal roots of M1	23
Width of palatal portion of palatine immediately behind M3	18.5
Width of premaxillaries at anterior end	38.5
Dorso-ventral depth of orbit	*a*36.7
Greatest depth of zygomatic arch below orbit	41.7
Length of diastema between C and P2	36.7
Least distance between alveolar borders of lateral incisor and canine	20.3
Height of canine tuberosity	36.7

a, approximate.

MEASUREMENTS OF SUPERIOR DENTITION

Length, anterior end of alveolus for medial incisor to posterior side of M3	162 · mm.
Length, anterior side of canine to posterior side of M3	134.4
Length, anterior side of P2 to posterior side of M3	82.2
Length of premolar series, P2 to P4 inclusive	32.8
Length of molar series	50
Superior canine, anteroposterior diameter	a15.5
Superior canine, transverse diameter	8.4
P2, anteroposterior diameter	9.2
P2, transverse diameter	10
P3, anteroposterior diameter	11.4
P3, transverse diameter	12.4
P4, anteroposterior diameter	11.5
P4, transverse diameter	14.2
M1, anteroposterior diameter	14.5
M1, transverse diameter	13.4
M2, anteroposterior diameter	18.8
M2, transverse diameter	15.7
M3, anteroposterior diameter	17.3
M3, transverse diameter	15

a, approximate.

Limb Elements

A proximal portion of the fused radius and ulna (fig. 5) agrees in size with *Platygonus leptorhinus* so far as this is indicated by the preserved specimen from Rancho La Brea. A fourth metacarpal, no. 4403 (fig. 6), is slightly shorter than the corresponding element in *P. leptorhinus*. The metapodial exhibits a small facet along the inner proximal margin for the third metacarpal. A small contact surface was possibly present at the proximo-lateral end which is now broken away. A single astragalus, no. 24066, Univ. Calif. Coll. Palae. (fig. 7), is somewhat smaller than the corresponding element in *P. leptorhinus*. This specimen possesses proportions similar to those of the astragalus in the Kansas species. An ungual phalanx (figs. 8*a*, 8*b*) presumably belongs to this dicotyline species from the asphalt deposit. In shape it much resembles the toe bones of *Platygonus*. The ventral surface is broad and flat. In lateral aspect (fig. 8*a*) the dorsal surface is seen to be inclined at an angle of approximately 27° to the horizontal plane of the ventral surface.

MEASUREMENTS

Radius-ulna, no. 4402:

Greatest transverse width of articulating surface for humerus	30.3 mm.
Least width of joined radius and ulna	27

Fourth metacarpal, no. 4403:
Greatest length.. 80.1 mm.
Least width of shaft... 12
Least anteroposterior diameter of shaft............................. 12.8

Ungual phalanx, no. 4401:
Anteroposterior diameter... 28.3
Greatest proximal width.. 14.3
Greatest height.. 19.2

Astragalus, no. 24066:
Greatest length along inner side.................................... 34.4
Greatest width of distal end....................................... 22.2
Least width across dorsal surface at distal end of trochlea for tibia....... 15.8

Conclusion

The information gained from a study of peccary remains from
Rancho La Brea, consisting of a fragmentary skull, the superior den-
tition, and a few skeletal parts, indicates the presence there of the
genus *Platygonus*. A close relationship exists between the species
from the asphalt beds and *P. compressus* and *P. leptorhinus*. Cer-
tain characters of the skull suggest, however, the possibility of
specific or subspecific separation from other known American forms.

MAMMALIA

FAUNAS OF CALIFORNIA, OREGON, AND IDAHO
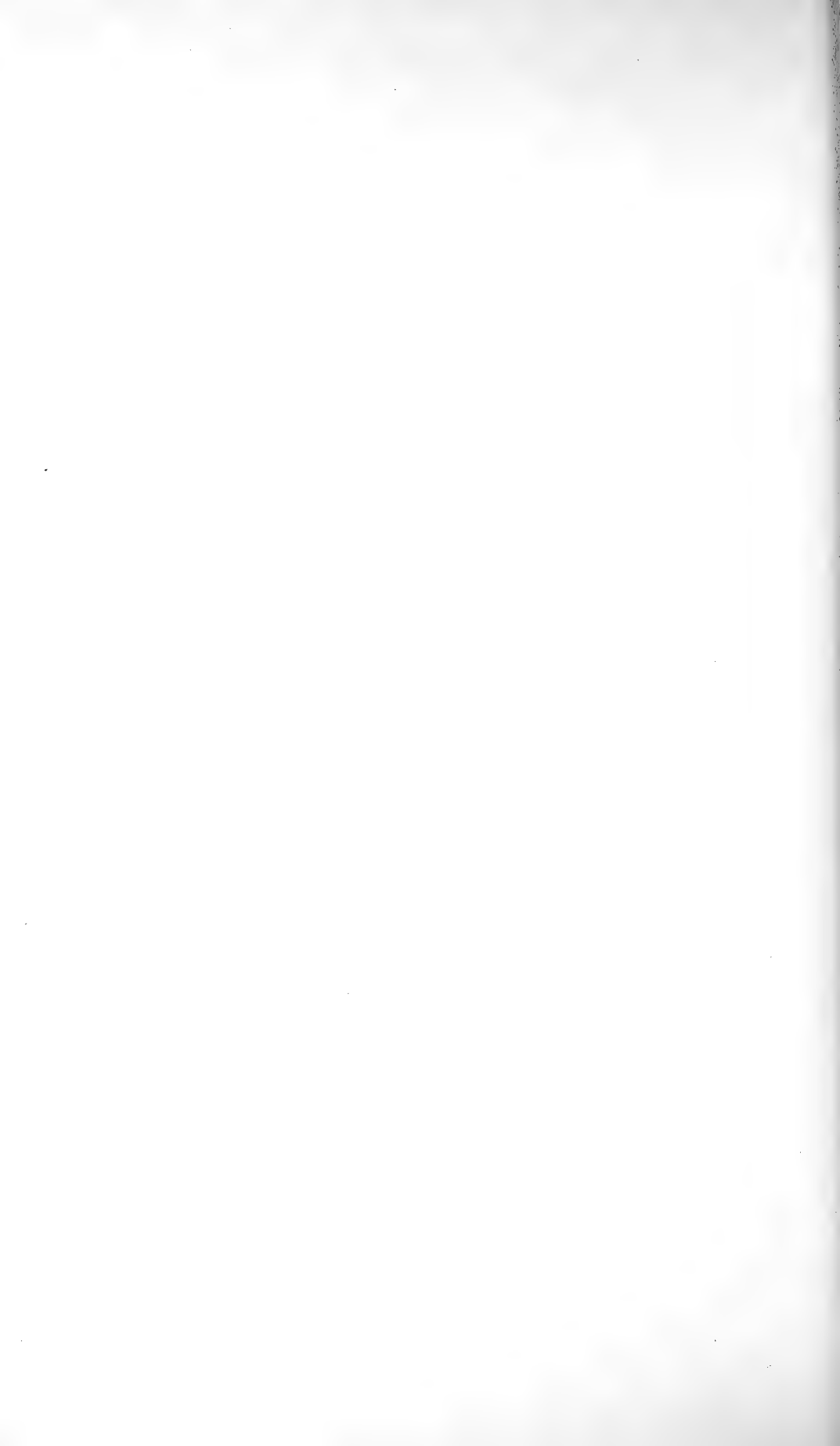
MAMMALIAN REMAINS FROM A LATE TERTIARY FORMATION AT IRONSIDE, OREGON

INTRODUCTION

IN DECEMBER, 1915, Dr. W. D. Matthew of the American Museum of Natural History kindly called the attention of the writer to a reported occurrence of fossil mammalian remains at a locality near Ironside, Malheur County, Oregon, the information having come to Dr. Matthew through Mr. H. E. Anthony, of the Department of Mammalogy and Ornithology in the American Museum. In subsequent correspondence Mr. Anthony informed the writer that a number of specimens had been obtained by his father, A. W. Anthony, at various localities in Malheur County, Oregon. In later correspondence, Mr. A. W. Anthony kindly furnished to the writer such information regarding the localities as was available. These discoveries suggested the occurrence of a fauna of importance in consideration of the history of mammals in the northern portion of the Great Basin province, and the writer accepted the invitation of Mr. Anthony to visit the Ironside region and examine the fossil-bearing formation.

In company with Dr. J. P. Buwalda of the University of California the writer had the opportunity to make a hurried survey of this region in June, 1916. The writer desires to express his appreciation of the courtesies extended by Mr. and Mrs. Anthony during the visit to Ironside, and for several interesting mammal specimens presented to the University by Mr. Anthony. It is also a pleasure to acknowledge the courtesy of Dr. Matthew and Mr. H. E. Anthony in furnishing the original information leading to investigations of this locality.

OCCURRENCE AND AGE

The Ironside region, in which the mammalian finds are reported, is situated on the extreme northern border of Malheur County,

Oregon, and is about thirty miles west of the middle of the eastern border of the state. This region lies at the southeastern base of the Blue Mountains, and is at the northern end of the great series of broken plains and short mountain ranges extending through southeastern Oregon into Nevada. The Ironside region is drained by Willow Creek, a tributary of Malheur River.

The beds in which the fossil remains were found by Mr. Anthony are in the immediate vicinity of Ironside Post Office. Some of the exposures are at an elevation of 3800 feet above sea-level. Somewhat to the east of Ironside similar sedimentary formations seem to be situated at an elevation of at least 4000 feet.

The mammal-bearing formation consists of buff sandy shales and shales with but little sand. The beds stand at varying angles ranging up to a degree of inclination of at least 20 degrees.

Locality 3037, at which the most important specimens were found, is located about three-fourths of a mile southwest of Ironside Post Office. At this locality, Mr. Anthony secured several fragments of upper teeth of *Hipparion*, a well-preserved lower tooth constituting the type of *Hipparion anthonyi*, a fragment of a rhinoceros tooth, and fragments of mastodontine teeth. One quarter of a mile south of locality 3037 Elmer Molthan obtained a well-preserved tooth of a mastodontine form apparently derived from beds not widely different in age from those at locality 3037.

The equid remains found in the sediments near Ironside represent a form most closely approaching in stage of evolution the *Hipparion* species from the Ricardo Pliocene. The stage of evolution of the fragmentary equid remains from Ironside is approximately that of the *Hipparion* species known from formations of the Great Basin and Pacific Coast provinces generally referred to the Pliocene. There is good reason for believing that the sediments at Ironside are not younger than middle Pliocene and not older than late Miocene. Future investigations should bring out more exactly the age relation of this formation to the Rattlesnake Pliocene of the John Day Valley. The fauna listed from the Idaho formation by Lindgren[1] in his important papers on the Tertiary formations of southwestern Idaho contains as one of its important elements equid forms which have been referred to *Equus*, and there can be no doubt that the

[1] Lindgren, W., 20th Ann. Rep. U. S. Geol. Surv., Part 3, p. 99, 1900.

fauna at Ironside is not contemporaneous with that portion of the Idaho formation from which Lindgren's Idaho fauna was obtained.

At the present time some of the important problems in Tertiary geology and palaeontology of the Great Basin region depend upon an understanding of relationships between the John Day section and that of the Idaho region. By reason of its geographic situation the occurrence of mammal remains at Ironside may ultimately be of large service in the work of determining the time-relations between the Idaho sequence of faunas and the sequence of the John Day region. The Ironside locality is so situated that mapping of the region will make possible a determination of the stratigraphic relations of the sediments to the formations of the Snake River region of Idaho. Large exposures of sedimentary formations extend with few apparent interruptions from Ironside along Willow Creek and Malheur River to the type areas of the Idaho and Payette formations of the Snake River Valley. Some of these exposures presumably represent the Idaho formation, but it is not improbable that several formations or several stages of the later Tertiary are represented. The Ironside locality is also situated near the John Day Valley, in which there is represented the best stratigraphic section and the best palaeontologic sequence known as yet in the Great Basin province. It is probable that further palaeontologic and geologic studies will make it possible for us to understand the relation between the beds at Ironside and the John Day section. There is further the possibility that we may be able to determine the relation of the formation at Ironside to a great series of Tertiary deposits on the south side of the Blue Mountains, immediately to the south of the John Day Valley. The exposures on the south side of the Blue Mountains presumably represent a large part of the sequence of formations and faunas known within the John Day Valley.
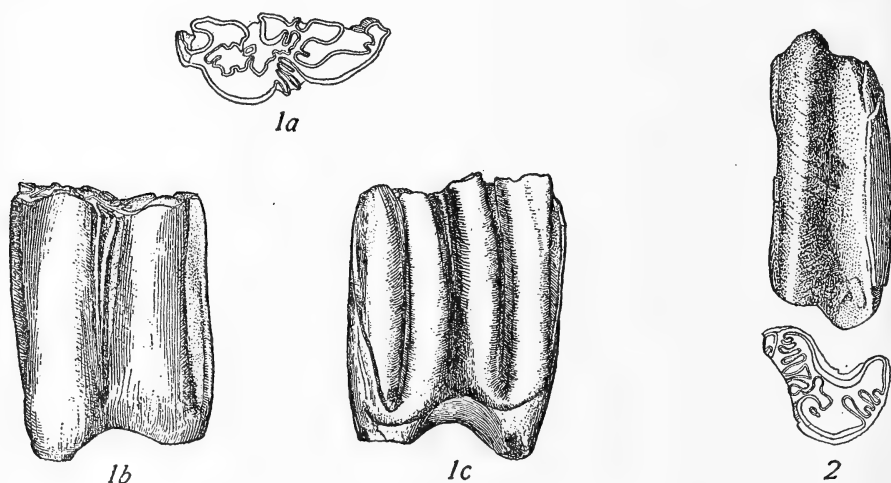
HIPPARION ANTHONYI, n.sp.

Type specimen a second lower premolar, no. 22351, from Tertiary beds exposed three-fourths of a mile south of Ironside, Malheur County, Oregon.

The species is represented by a single tooth presented by A. W. Anthony of Ironside, Oregon. The horizon at which this specimen was found is presumed to be early Pliocene or latest Miocene.

Crown of medium height, narrow transversely. Enamel pattern showing uncommonly strong secondary plications. Several very strong secondary plications forming a sheaf of projecting folds on anterior side of hypoconid.

Specimen 22351 (figs. 1*a* to 1*c*) differs from *Merychippus* and *Pliohippus* in its greater relative size and stage of advance of the metaconid-metastylid column and entoconid, and in greater complication of its enamel folds. Of the Great Basin and Pacific Coast province equids *Hipparion mohavense callodonte* of the Ricardo Pliocene most nearly approaches the form from Ironside. In the West Coast *Merychippus* and *Pliohippus* species the metaconid-metastylid column is relatively shorter anteroposteriorly, and wider transversely, and the entoconid is not filled out to the same extent

1a

1b　　　*1c*　　　2

Figs. 1*a* to 1*c*. *Hipparion anthonyi* Merriam. P$\bar{2}$, type specimen, no. 22351, natural size. Fig. 1*a*, occlusal view; fig. 1*b*, outer view; fig. 1*c*, inner view. From late Tertiary beds near Ironside, Oregon.

Fig. 2. *Hipparion anthonyi* Merriam?. Fragment of an upper cheek-tooth, no. 22355, natural size. From late Tertiary beds near Ironside, Oregon.

on the antero-internal angle. In general the entoconid of *Merychippus* and *Pliohippus* species is truncated obliquely on the antero-internal angle by a plane or curved face, extending outward and forward from the inner side, while in *Hipparion* this region is expanded and the cross-section of the entoconid tends to take on a rectangular outline, instead of the approximately triangular section seen in *Merychippus*, or the triangular to imperfectly rectangular but anteroposteriorly short section seen in *Pliohippus*.

In no Great Basin or Pacific Coast species of *Merychippus*, *Protohippus*, or *Pliohippus* known to the writer does the enamel show

such a high degree of secondary folding as in the specimen 22351 from Ironside. In *Hipparion mohavense callodonte* the enamel folds show much secondary crinkling, though less than in the Ironside form. The crown of *H. m. callodonte* is slightly larger and relatively thicker transversely, and the entoconid fuller on the antero-internal angle. In the type specimen of *H. m. callodonte* there are two small folds on the antero-external side of the hypoconid, but these folds are smaller than those in this position on the type of *H. anthonyi*. In other specimens from the Ricardo beds the structure differs more from that of no. 22351 than in the case of the type specimen of *H. m. callodonte*.

Of the *Hipparion* species from the northern end of the Great Basin, *Neohipparion leptode* of the Thousand Creek Pliocene shows a single very strong fold on the anterior side of the hypoconid, but the enamel is otherwise comparatively simple and the tooth crown in the type specimen, a second lower molar, is extremely narrow. No specimen of $P\bar{2}$ of *N. leptode* is known. From the Rattlesnake Pliocene of the John Day region a specimen with a tooth crown of exactly the same height as the type specimen of *H. anthonyi* shows the enamel very much simpler and the crown relatively very much thicker transversely. $P\bar{2}$ of *Hipparion condoni* from the Ellensburg formation is unknown. The enamel pattern in *H. condoni* is fairly complicated, but there is much less crinkling in long teeth than in the relatively short teeth of the type of *H. anthonyi*. There is a small fold on the anterior side of the hypoconid in a posterior premolar. The size of the crowns in *Hipparion condoni* suggests a type near the size of the Ironside specimen. Other characters indicate that the two forms are not specifically identical.

From such evidence as may be obtained from the single tooth available it may be concluded that no. 22351 from Ironside represents a species distinct from any thus far described in the Great Basin region and that the stage of evolution is not far from that of the Ricardo hipparions. This would indicate that the deposits near Ironside are of early Pliocene or late Miocene age.

A single fragment, no. 22355 (fig. 2), of an upper cheek-tooth from the deposits near Ironside consists of a cement-filled fossette with the enamel wall. The wall shows very strong plications, eight folds on one side and four on the other. This fragment evidently represents a *Hipparion* form similar in character to *H. anthonyi*, and it

may be considered to represent that species.   The form of fossette and degree of complication of the enamel folds bordering it suggest the character of the Rattlesnake Pliocene species with most complicated enamel.

COMPARATIVE MEASUREMENTS

	No. 22351 Ironside	H. m. callodonte No. 21311 Ricardo
$P\bar{2}$, anteroposterior diameter	27.8 mm.	28.4
$P\bar{2}$, transverse diameter across hypoconid	11.4	12

TETRABELODON?, sp.

A single lower cheek-tooth (no. 22883, fig. 3) found by Mr. Elmer Molthan one quarter of a mile south of locality 3037 near Ironside, Oregon, represents a large mastodontine form presumably from the
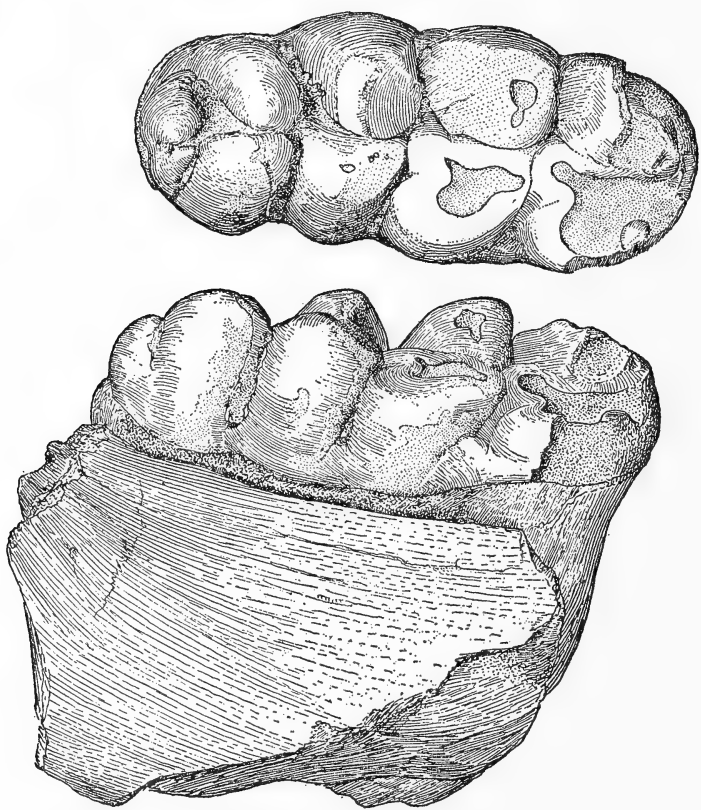
FIG. 3.   Tetrabelodon?, sp.   Lower cheek-tooth, no. 22883, natural size.   Outer and occlusal views.   From late Tertiary beds near Ironside, Oregon.

same formation and from approximately the same horizon as the teeth described as *Hipparion anthonyi*. The low conical tubercles are lightly connected transversely, and a few accessory tubercles are situated in the transverse valleys. This form resembles a type found in Great Basin beds referred to Pliocene or late Miocene, but the Pliocene mastodontine forms of this province are as yet very imperfectly known, and until further comparative studies have been made it is not possible to make satisfactory determination of the species represented by this specimen. It is, however, of importance to place on record the occurrence of this form.

Two fragments of mastodontine teeth from locality 3037 represent a type which does not give evidence of differing from specimen 22883 found by Mr. Molthan.

Measurements of No. 22883

Greatest anteroposterior diameter ....145 mm.
Greatest transverse diameter across second transverse crest from anterior
   end..62

Rhinocerotid, indet.

A fragment of an upper rhinoceros cheek-tooth from locality 3037 represents an indeterminate form. It is possible that future studies with the use of exceptionally good material for comparison may make possible an approximate determination of this tooth. For the present it is desirable to record the occurrence of rhinocerotid remains at this locality.

Transmitted December 18, 1916

NEW MAMMALIA FROM THE IDAHO FORMATION

CONTENTS

INTRODUCTION

IN ATTEMPTING to work out a correlation scheme of the Cenozoic formations in the Great Basin region, the writer has found the Idaho formation particularly difficult to interpret with regard to its stratigraphic relations and to its fauna. In the summer of 1916 the principal exposures in southwestern Idaho were visited in company with Dr. J. P. Buwalda in the interests of the United States Geological Survey. In the course of this investigation a number of significant collections of mammalian remains were obtained. In the material secured there are a few new forms to which it is necessary to make reference in several papers discussing phases of the Idaho problem. A full discussion of the Idaho fauna with particular reference to its affinities will be presented in a later paper.

ISCHYROSMILUS?[1] IDAHOENSIS, n. sp.

Type specimen, no. 22343, from beds referred to the Idaho formation at locality 3036C, near Froman Ferry on the Snake River in southwestern Idaho. The type consists of the anterior two-thirds of the left ramus of a mandible with the roots of all of the teeth.

[1] *Ischyrosmilus*, new genus, founded upon *Machaerodus? ischyrus* Merriam. Genus characterized as follows: mandible massive; flange clearly marked, relatively wide anteroposteriorly, slightly wider than in *Smilodon*, not as strongly developed as in *Machaerodus*; diastema much as in *Machaerodus* but shorter than in *Smilodon*. P$\overline{3}$ very small with one root. P$\overline{4}$ with single posterior cusp or incipient division of this cusp. For more extended discussion, see Merriam, J. C., Tertiary Mammalian Faunas of the Mohave Desert Region, Univ. Calif. Publ., Bull. Dept. Geol., in press.

Specimen no. 22343 (fig. 1) represents a very large sabre-tooth approximating the dimensions of the largest individuals of *Smilodon californicus* from Rancho La Brea. The Idaho specimen differs from the typical *S. californicus* in dentition by the presence of a small P3̄. This tooth is found in a small percentage of the Rancho La Brea sabre-tooth specimens, but is normally absent. The Idaho mandible differs from that of *S. californicus* very decidedly in the size and proportions of the flange below the diastema. In *S. californicus* the flange is comparatively short, ending posteriorly rather

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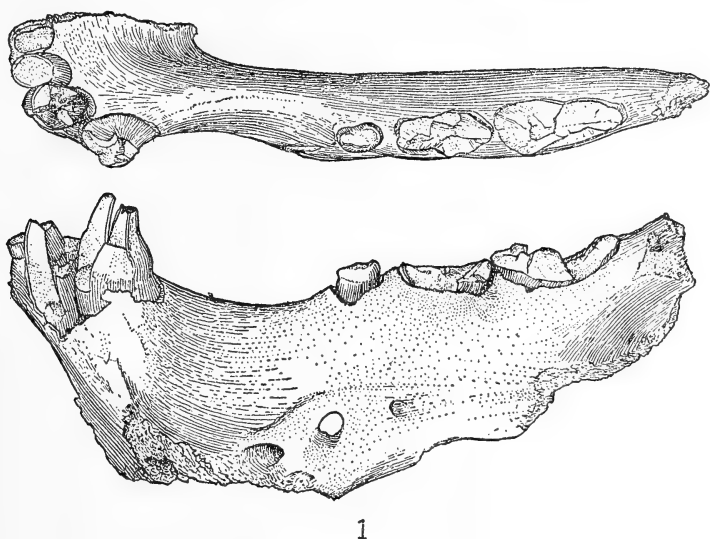
Fig. 1. *Ischyrosmilus? idahoensis*, n. sp. Outer and superior views of mandible. Type specimen, no. 22343. × ½. From beds referred to Idaho formation, near Froman Ferry, Idaho.

abruptly some distance in front of P3̄. In no. 22343 the posterior end of the flange fades out below the anterior end of P4̄. A flange of the type seen in the Idaho specimen is found also in *Ischyrosmilus ischyrus* of the Tulare Pliocene of California, in *I. osborni* of the Ricardo Pliocene, and in *Machaerodus palaeindicus* of the upper Siwalik beds of India.

The Idaho specimen possesses three mental foramina in contrast to the one large foramen seen in *Smilodon californicus*.

The tooth crowns in no. 22343 are unfortunately all broken away with the exception of a considerable part of the lower canine and

about one-half of the crown of P$\overline{3}$. Sufficient portions of the roots remain to give an estimate of the relative dimensions of the teeth. These measurements indicate that P$\overline{4}$ is relatively smaller and M$\overline{1}$, larger than in *S. californicus*. As these measurements are based upon the upper portions of the roots or upon the neck of the teeth they are not exactly comparable with the measurements from perfectly preserved crowns of *S. californicus*, as the lower region of the crowns has a somewhat longer anteroposterior diameter than the upper portion of the root or the neck.

The incisors of the Idaho form appear somewhat thicker transversely than in the typical species of *Smilodon* from Rancho La Brea.

With the fragmentary material available it is impossible to draw very satisfactory conclusions as to the systematic position and age of the Idaho sabre-tooth. The presence of a well developed P$\overline{3}$ taken with the unusual anteroposterior diameter of the flange and the relatively large size of M$\overline{1}$ suggests affinity with the Pliocene genus *Ischyrosmilus* represented in the Ricardo and in beds referred to the Tulare, of California. *Machaerodus palaeindicus* of the Siwalik beds differs from all of these forms in possession of a two-rooted P$\overline{3}$.

While it is true that P$\overline{3}$ may be well developed in adult individuals of *Smilodon californicus* as in the Idaho specimen, this occurrence is so exceptional that the chance of having this tooth occur in an isolated individual would be very small.

So far as the evidence of this sabre-tooth is concerned, it might be presumed to suggest a somewhat earlier geologic stage than that of *S. californicus*. It should also be noted that the Idaho form is much larger than the specimens from the Ricardo and the Tulare and might therefore be later than the horizons represented by the Ricardo and Tulare faunas.

COMPARATIVE MEASUREMENTS

	I. ischyrus No. 22343 No. 8140 Idaho Tulare		I. osborni No. 19476 Ricardo	S. californicus No. 22180 Rancho La Brea
Height of mandible below anterior end of P$\overline{4}$.	49 mm.	41.2	34.7	40.3
Thickness of mandible below anterior end of P$\overline{4}$.	22.2	....	....	18.3
Height of mandible below anterior end of P$\overline{3}$.	52	41.4	36	37
Length anterior side inferior canine to posterior side M$\overline{1}$.	135.2	107	81	134.2

	I. ischyrus No. 22343 Idaho	I. ischyrus No. 8140 Tulare	I. osborni No. 19476 Ricardo	S. californicus No. 22180 Rancho La Brea
Length anterior side P3̄ to posterior side of M1̄	71.6 mm.	61.7	....	65.5
Length of diastema	46.4	33.5	26.5	51.5
C, anteroposterior diameter	19.2	14.5	a10	16.2
P3̄, anteroposterior diameter	10	7	a6.4	9.9?
P4̄, anteroposterior diameter	23.7	20	16.7	25
M1̄, anteroposterior diameter	33.2	28.5	24	30
M1̄, greatest transverse diameter	13.5	15	11	15

a, approximate.   All measurements of teeth approximate on neck or base of crown.
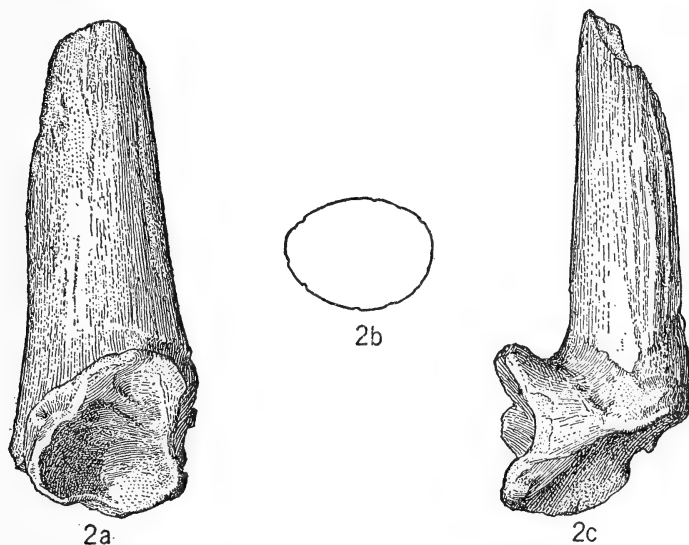
FIGS. 2*a* TO 2*c*. *Neotragocerus lindgreni*, n. sp. Horn-core. Type specimen, no. 3941, U. S. Nat. Mus. × ½. Fig. 2*a*, median view; fig. 2*b*, cross-section at middle height; fig. 2*c*, posterior view.   From beds referred to the Idaho formation three miles east of Boise, Idaho.

NEOTRAGOCERUS LINDGRENI, n. sp.

Type specimen, a horn-core, no. 3941, collection of U. S. Geological Survey assembled by W. Lindgren.   Found three miles east of Boise, Idaho, by Edward S. White.   Occurrence doubtfully in Idaho beds.

The horn-core (figs. 2*a* to 2*c*) obtained by Lindgren from the Boise region represents an antelope of the *Tragocerus* type and approaching the characters of the Snake Creek Pliocene form described as *Neotragocerus improvisus* by Matthew and Cook.[2]

[2] Matthew, W. D., and Cook, H. J., Bull. Amer. Mus. Nat. Hist., vol. 26, p. 413, 1909.

The Idaho specimen is more slender than *N. improvisus,* and may show slightly greater lateral compression. It is also more slender, longer and more distinctly flattened transversely than horn-cores of the Recent mountain goat, *Oreamnos.* Additional material will be required before the position of the species represented by this specimen can be clearly determined.

Equus idahoensis, n. sp.

Type specimen, an upper cheek-tooth, no. 22348, from locality 3036C in beds referred to the Idaho formation near Froman Ferry on the Snake River, eight miles southwest of Caldwell, Idaho.

Referred to this species is also a lower premolar, no. 22347, from beds referred to the Idaho formation at Froman Ferry.

Cheek-teeth large and heavily cemented, characters as in typical *Equus,* excepting in the nature of the protocone of the upper cheek-teeth and of the inner gutter between metaconid and metastylid columns of the lower cheek-teeth.

Protocone very short anteroposteriorly but distinctly concave on the inner border. Character of the protocone approaching that of *Equus stenonis* of the European Pliocene. Gutter on inner border of metaconid-metastylid column of lower cheek-teeth narrow and angular as in *Pliohippus.*

An upper tooth, no. 22348, from locality 3036C in Idaho beds near Froman Ferry on the Snake River represents an animal as large as *Equus pacificus* or the largest individuals of *E. occidentalis.* The crown (fig. 3) is very heavily cemented. Unfortunately it has suffered so much wear that the original length and curvature cannot be estimated. The fossettes are very narrow, as might be expected at this stage of wear, and show plications of such extent as to indicate that considerable folding of the walls would be shown at an early or middle stage of wear. The outer styles are strong. The outer walls of protocone and paracone are much flattened. The protocone is small and short anteroposteriorly, the stage of anteroposterior abbreviation suggesting that in *Pliohippus.* As in *Equus,* the anterior border of the protocone is prolonged anteriorly much beyond the isthmus, connecting the protocone with the protoconule. The inner border of the protocone is distinctly concave, as in *Equus.* The characters of this tooth are those of *Equus,* with the exception of shortness of the protocone, which suggests *Pliohippus.* The characters of the anterior and inner borders of this pillar are clearly those of *Equus.* Anteroposterior shortness of the protocone occurs in a few species of *Equus,* especially the earlier members of the group.

An upper cheek-tooth, no. 22346 (fig. 4), was obtained at locality 3039, in bluffs assumed to be Idaho exposed along the north bank of the Payette River, about four and one-half miles southeast of the town of Payette. The anterior portion of the protocone of this specimen is broken away. The characters of this tooth do not seem in any particular to differ from those of the *Equus*. The posterior portion of the protocone column is shorter than this region often appears in *Equus*, but matches the proportions commonly seen in *Equus occidentalis*. There is good reason for considering that this tooth represents a typical *Equus* species not far removed from *E. occidentalis*. It differs from average specimens of *E. occidentalis* in greater lateral compression of the fossettes, and in the more pronounced complication of the enamel borders of the fossettes.
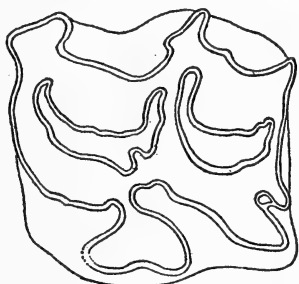
Fig. 3. *Equus idahoensis*, n. sp. P4, occlusal view. Type specimen, no. 22348, natural size. From beds referred to Idaho formation, near Froman Ferry, Snake River, Idaho.

A lower premolar, no. 22347 (fig. 5), from locality 3036C in presumed Idaho beds at Froman Ferry represents a large and very advanced horse. The crown is long and heavily cemented; the outer faces of the protoconid and the hypoconid are flat. The metaconid-metastylid column is long anteroposteriorly and the valleys anterior and posterior to this column are narrow transversely. In all these characters this tooth distinctly resembles *Equus*. In a single feature, namely, in the acuteness of the inner fold of the metaconid-metastylid column, this tooth shows resemblance to advanced forms of *Pliohippus*. In *Equus* the gutter is commonly broad and flat. Occasionally, however, it may be narrow and the inner end of the fold acute. On the whole this tooth is of the *Equus* type with only a single suggestion of *Pliohippus* in its structure.

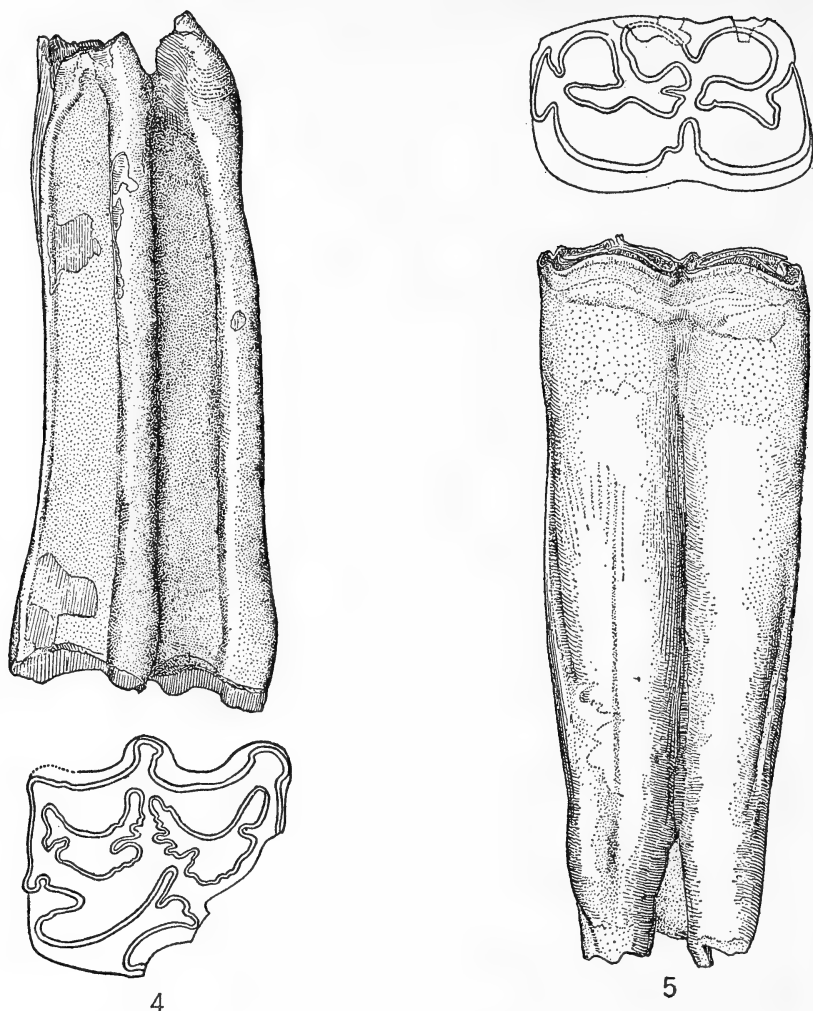Compared with the teeth of *Equus* from the Columbia River bluffs

4

5

FIG. 4. *Equus idahoensis?* M1?, occlusal and outer views, no. 22346, natural size. From beds referred to Idaho formation, bluffs on north side of Payette River about four and one-half miles southeast of Payette, Idaho.

FIG. 5. *Equus idahoensis?* P4̄, outer and occlusal views, no. 22347, natural size. From beds referred to Idaho formation, near Froman Ferry, Snake River, Idaho.

near Ringold,[3] Washington, upper tooth 22348 is somewhat larger and the protocone is much shorter anteroposteriorly. The upper tooth from the Idaho beds at locality 3039 is not apparently less

[3] Merriam, J. C., and Buwalda, J. P., Univ. Calif. Publ. Bull. Dept. Geol., vol. 10, p. 256, 1917.

Equus-like than the teeth from near Ringold, unless it be in the character of the anterior portion of the protocone, which is unfortunately broken away in the Payette River specimen. The portion of the protocone remaining in the Payette River specimen is perhaps a little thicker transversely than in the Ringold specimen, but a complete protocone might show more advanced lateral compression.

The lower tooth from locality 3036C from the Snake River is slightly more Pliohippus-like than a large lower tooth from the exposures near Ringold. In the Idaho specimen the inner faces of the protoconid and hypoconid are a little less flattened, and the inner groove of the metaconid-metastylid column is much narrower and much more acute. In this respect the Idaho specimen is more Pliohippus-like than that from the beds near Ringold.

A number of specimens representing foot-bones of a large horse from beds referred to the Idaho show no evident characters distinguishing them from the corresponding elements of Pleistocene species of *Equus*.

COMPARATIVE MEASUREMENTS

	E. idahoensis P4? No. 22348	E. idahoensis? M1? No. 22346	Large Individuals E. occidentalis P3	E. pacificus P4
Anteroposterior diameter	35.5 mm.	33	34	34.5
Transverse diameter	34.8	30.6	28.7	32.5
Height of crown	24.7	81	....	....
	No. 22347 P4		P4	
Anteroposterior diameter	34	....	34.5	....
Transverse diameter	18.8	....	18.3	....
Anteroposterior diameter of metaconid-metastylid column	19.8	....	....	....
Height of crown	72	....	....	....

RELATIONSHIPS OF PLIOCENE MAMMALIAN FAUNAS FROM THE PACIFIC COAST AND GREAT BASIN PROVINCES OF NORTH AMERICA

CONTENTS

INTRODUCTION

Much less than a decade ago the imperfection of our knowledge of North American Pliocene mammal faunas was so evident that it merited comment. Questions frequently arose concerning the relative paucity of mammalian remains and of formations representing this period, and explanation of the absence of Pliocene records included suggestion that the faunas had been largely described as Miocene or Pleistocene, or that conditions of relief had been unfavorable for accumulation of continental deposits.

As recently as 1909 Pliocene mammalian life known west of the Rocky Mountains was practically all comprised within seven more or less doubtfully determined species from the Rattlesnake Pliocene of the John Day Valley and several doubtful species from the imperfectly understood Idaho beds of Idaho. At that time the Great Plains Pliocene fauna included the Blanco of Texas, and the Republican River doubtfully referred to the same period. The Atlantic fauna consisted of the intermixed Alachua Pliocene and Peace Creek Pleistocene, and offered a serious problem in age determination by reason of this mixture.

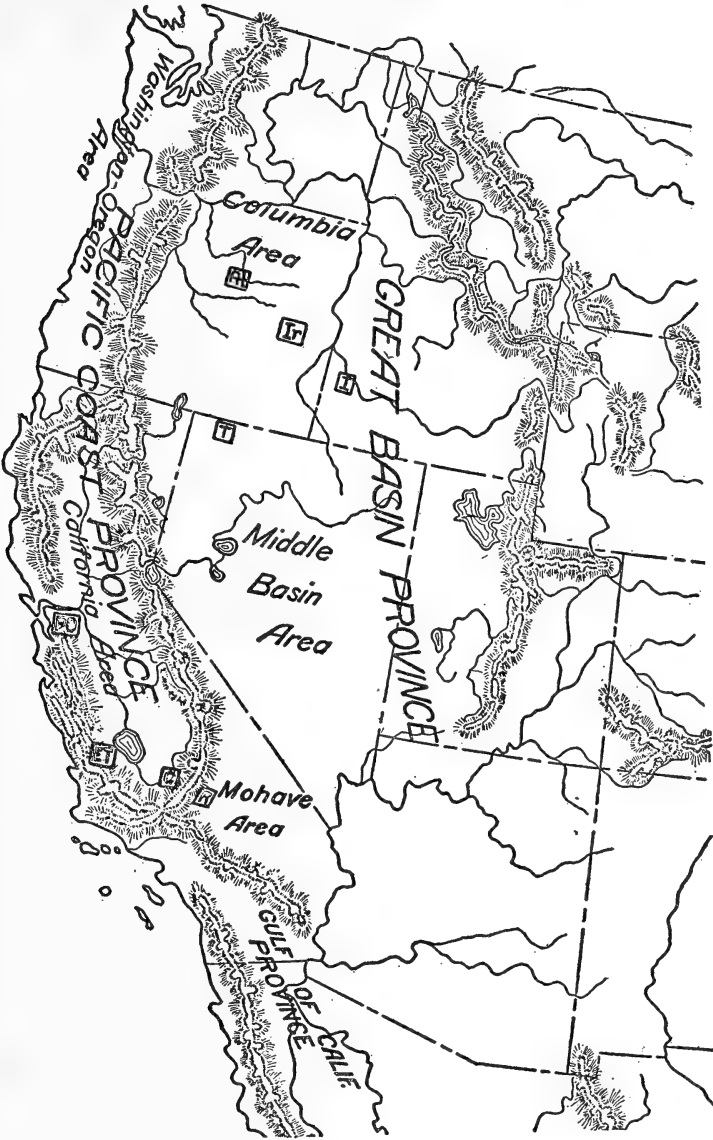Seven years ago description of the Snake Creek fauna, the richest

FIG. 1. Outline map illustrating principal occurrences of Pliocene mammal faunas in Tertiary provinces of that portion of United States west of the Wasatch Range. The most important localities are indicated as follows: I, Idaho beds; Ir, Ironside Pliocene; Rt, Rattlesnake; T, Thousand Creek; PO, Pinole Tuff-Orinda; ET, Etchegoin-Tulare; C, Chanac; R, Ricardo.

of all American Pliocene mammal assemblages, by Matthew and Cook[1] gave the first definite indication of existence of an important Pliocene stage other than that of the Blanco. Immediately following the first study of the Snake Creek came discovery of the interesting Thousand Creek Pliocene fauna[2] of Nevada, with suggestion of similarity to the Nebraska Snake Creek in a number of peculiar types, especially in the presence of antelopes like those of the Old World Pliocene and Miocene. Following the discovery of the Thousand Creek there came to light on the western border of the continent the Ricardo fauna[3] of the Mohave Desert, the Etchegoin,[4] and the Pinole Tuff-Orinda[5] faunas of middle California, while the Rattlesnake fauna of eastern Oregon was increased to dimensions comparable to those of the Thousand Creek, Ricardo, and Blanco. Additional information regarding the composition and age of the interesting fauna of the Idaho formation in southwestern Idaho has also been obtained.

Through the work of Dr. E. H. Sellards,[6] the Alachua fauna of Florida has received valuable additions, and has had separated from it a considerable number of the elements of more modern aspect, which have heretofore confused interpretation of this assemblage.

Although at the present time American Pliocene mammal faunas are not as fully known as those of other Tertiary divisions, progress in accumulation and classification of material within the past five years has been relatively more rapid than for any other division of the Cenozoic. We begin now to see for the first time the broader world relationships of our higher vertebrate Pliocene life.

Of American Pliocene faunas, those represented in the Pacific Coast and Great Basin provinces have been so imperfectly known

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[1] Matthew, W. D., and Cook, H. J., A Pliocene fauna from western Nebraska, Bull. Amer. Mus. Nat. Hist., vol. 26, pp. 361–414, 1909.

[2] Merriam, J. C., Tertiary mammal beds of Virgin Valley and Thousand Creek in northwestern Nevada, pt. 2, Vertebrate faunas, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 199–304, pls. 32–33, 1911.

[3] Merriam, J. C., Extinct faunas of the Mohave Desert: their significance in a study of the origin and evolution of life in America, Pop. Sci. Monthly, pp. 245–264, March, 1915.

[4] Merriam, J. C., Tertiary vertebrate faunas of the North Coalinga region of California, Trans. Amer. Philos. Soc., n. s., vol. 22, pt. 3, 44 pp., 1915.

[5] Merriam, J. C., Vertebrate fauna of the Orindan and Siestan beds in middle California, Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, pp. 373–385, 1913.

[6] Eighth Ann. Rep. Florida Geol. Surv., pp. 92–100, 1916.

that it seems desirable to present a general statement of their composition and relationships for use in consideration of certain fundamental faunal problems involved in later Cenozoic history.

American Pliocene Faunas

Pacific Coast Province

At the present time there are known in the Pacific Coast province at least four important occurrences of Pliocene mammalian remains, and there are probably represented in these stations four fairly distinct stages or horizons.   These are the upper and middle and lower Etchegoin on the western border of the San Joaquin Valley; the Tulare overlying the Etchegoin of the Great Valley of California; the Chanac formation of the Tejon Hills at the southern end of the San Joaquin Valley, and the Pinole Tuff-Orinda section of the Mount Diablo or San Francisco Bay region.   Of these formations, the Etchegoin-Tulare section is not less than 10,000 feet in thickness; the Pinole Tuff-Orinda section represents at least 5000 feet of strata; the Tejon Hills section so far as known represents only a few hundred feet of accumulation.

The faunal sequence of the Pacific Coast region is exceptionally well represented in the *Etchegoin-Tulare section*, but the amount of material from the beds of that region is unfortunately scanty. Within the limits of the Etchegoin two or perhaps three faunal zones are known.   There is apparently a clear distinction between the upper zone characterized by the presence of *Pliohippus proversus*, a very advanced horse like the Blanco *Pliohippus*, and the middle zone distinguished by the presence of *Pliohippus coalingensis*, a typical *Pliohippus*.   Below the horizon of *P. coalingensis* several fragmentary specimens of *Hipparion* have been found, but as yet no remains of hipparions are known from the *P. coalingensis* and *P. proversus* zones.   The lowest beds have been discussed in a tentative way as the *Hipparion* zone.

In the Tulare formation overlying the Etchegoin no certainly authenticated occurrences of mammalian remains are reported. About twenty years ago a specimen of *Hyaenognathus*, a peculiar dog like *Borophagus* of the Blanco Pliocene, was found associated with *Ischyrosmilus*, a machaerodont cat, near the town of McKittrick, in a formation now presumed to be Tulare.

The fauna of the Tulare-Etchegoin section on the western border of the San Joaquin Valley is as follows:

FAUNA OF TULARE-ETCHEGOIN SECTION

TULARE

?Hyaenognathus pachyodon Merriam
?Ischyrosmilus ischyrus (Merriam)

ETCHEGOIN

Pliohippus proversus zone
    Pliohippus proversus Merriam
    Camelops or Pliauchenia, sp.
    Procamelus?, sp.
    Cervus or Odocoileus, sp.
    Tayassu or Mylohyus?, sp.
    Mastodon
    Testudo?, sp.
    Undetermined fragmentary fish remains
Pliohippus coalingensis zone
    Pliohippus coalingensis (Merriam)
    Pliohippus?, sp., small
    Procamelus?, sp.
    Platygonus?, sp.
?Hipparion zone
    Neohipparion molle Merriam
    Neohipparion, sp.
    Protohippus or Pliohippus, sp.

In the *Pinole Tuff-Orinda section* scattered remains have been found at a number of localities, but the best representation of the fauna found at any one station is that secured from the Pinole Tuff and Orinda on the border of San Pablo Bay. In these strata there have been obtained the following forms:[7]

PINOLE TUFF-ORINDA FAUNA, SAN PABLO BAY

Pliohippus, near fairbanksi Merriam
Pliohippus, sp.
Rhinocerotid, near Teleoceras
Antelope, near Sphenophalos
Mastodontine form
Edentate, megalonychid
Tephrocyon, sp.
Testudinate remains

[7] From unpublished manuscript of Merriam and Stock.

At localities in the Orinda, and in beds presumed to be higher than those of the horizons at San Pablo Bay, the following forms have been obtained:[8]

ORINDA FAUNA, CONTRA COSTA HILLS

Hipparion platystyle Merriam
Hipparion, near mohavense Merriam
Prosthennops, sp.
Procamelus, sp.
Pliauchenia, sp.
Tetrabelodon?, sp.
Dipoides lecontei (Merriam)

If any suggestion of sequence is given in the Pinole Tuff-Orinda section, it appears to be that *Hipparion* occurs at a horizon somewhat higher than that of the *Pliohippus* forms; but the stratigraphic succession is so imperfectly known that such a conclusion seems not at present to be fully warranted.

The *Tejon Hills fauna*[9] found in the Chanac formation at the southern end of San Joaquin Valley occurs in beds which rest upon marine San Pablo Upper Miocene, and are presumably unconformable upon that formation. The fauna includes the following forms:

CHANAC FAUNA

Protohippus tehonensis Merriam
Pliohippus, sp.
Hipparion gratum tehonense Merriam
Hipparion, near molle Merriam
Rhinocerotid, indet.
Prosthennops, sp.
Camelid, indet. large
Merycodus, near necatus Leidy
Proboscidean (Tetrabelodon?), sp.

In this fauna the hipparions are the most abundant forms. They represent two small species, one of which is very close to *Hipparion gratum* of the Great Plains region. The *Prosthennops* suggests the Pliocene species of the Great Valley of California. The *Merycodus* is near *necatus* Leidy, which appears both in the Barstow Upper

[8] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, pp. 373–385, 1913.

[9] Merriam, J. C., Mammalian remains from the Chanac formation of the Tejon hills, California, Univ. Calif. Publ. Bull. Dept. Geol., vol. 10, pp. 111–127, 1916.

Miocene and in the Ricardo Lower Pliocene of the Mohave Desert a few miles to the east.

Comparison of the Chanac fauna with the available Etchegoin and Tulare faunas shows that the Tejon Hills stage may be comparable to the Hipparion-bearing beds in the lowest portion of the Etchegoin section. The Pinole Tuff-Orinda fauna seems certainly older than the Pliohippus proversus zone of the Etchegoin. The fauna of the beds furnishing the best collections of the Pinole Tuff and of the lowest Orinda on San Pablo Bay is close to that of the Pliohippus coalingensis zone of the Etchegoin. The Tulare evidently represents the latest stage.

The sequence of Pliocene faunas and formations of the Pacific Coast province as we now know it is most satisfactorily expressed in a series of four stages. All four of these faunas may be present in one stratigraphic sequence in the North Coalinga region.

The stages are as follows:

Tulare...................... ?Hyaenognathus zone
Upper Etchegoin............. Pliohippus proversus zone
Middle Etchegoin........... Pliohippus coalingensis zone
Lower Etchegoin or Chanac.... Hipparion gratum tehonense or Hipparion molle zone

Great Basin Province

In the Great Basin region there are four important occurrences of Pliocene faunas. These are the Thousand Creek of the northern Nevada or Middle Basin area, the Ricardo of the Mohave Desert, the Rattlesnake of the John Day Valley, and the Idaho of southwestern Idaho.

The *Rattlesnake fauna* has unusual significance owing to exceptional clearness of stratigraphic relations of the beds in which it occurs. The Rattlesnake formation rests in marked unconformity in steep cliff section upon the Mascall, which contains a mammalian fauna of Middle or Upper Miocene age. Through the accumulated Rattlesnake deposits deep cañons have been cut, and in the lower reaches of these excavations are deposits containing a Pleistocene fauna. The age of the Rattlesnake formation is therefore limited on one side by a period of erosion and deformation succeeding accumulation of the Mascall Miocene, and on the other side by a period of erosion preceding accumulation of deposits of Pleistocene age.

Within the past field season a party from the Department of Palaeontology of the University of California has made intensive study of the Rattlesnake formation and fauna, and has increased the list of mammalian species considerably.

The mammal forms now known from the Rattlesnake formation are the following:[10]

<center>RATTLESNAKE FAUNA</center>

Carnivora
  ?Canis davisi Merriam
  Amphicyon, near amnicola Matthew and Cook
  Mustela, sp. *a*
  Mustela, sp. *b*
  Felis, large sp.
  Indarctos? oregonensis Merriam, Stock, and Moody
Edentata
  Megalonychid, gen. and sp. indet.
Rhinocerotidae
  ?Teleoceras fossiger (Cope)
Equidae
  Hipparion sinclairii Wortman
  Hipparion, near occidentale Leidy
  Hipparion, near anthonyi Merriam
  Pliohippus, near fairbanksi Merriam
  Pliohippus spectans (Cope)
Suidae
  Prosthennops, sp.
Camelidae
  Alticamelus altus (Marsh)
  Pliauchenia, sp.
  Procamelus, sp.
Antelopinae
  Sphenophalos, near nevadanus Merriam
  Ilingoceros?, sp.
Mastodontinae
  Tetrabelodon?, sp.
Rodentia
  Lepus?, sp.
  Dipoides?, sp.

Of the Rattlesnake horses, the best represented *Pliohippus* forms are much like those in the Pliohippus coalingensis zone of the Etche-goin, in the Thousand Creek, and in the Ricardo.   The *Hipparion*

[10] From unpublished manuscript of Merriam, Stock, and Moody.

species are like forms of the Thousand Creek and show some resemblance to a species from the Hipparion zone of the Pacific Coast province.

The Rattlesnake antelopes resemble those of the Thousand Creek fauna.

The *Thousand Creek fauna* is known from extensive exposures in the valley of Thousand Creek at the extreme northern border of Nevada. The stratigraphic relations of the Thousand Creek formation are unfortunately not as yet fully known, but there is every reason to consider that the beds are much later than those of the Virgin Valley Middle Miocene, which is of approximately the same facies as the Mascall Middle Miocene of the John Day region.

The fauna obtained in the Thousand Creek region is as follows:[11]

THOUSAND CREEK FAUNA

Reptilia
  Ophidian remains
Aves
  Branta, sp.
Insectivora
  Scapanus?, sp.
Carnivora
  Tephrocyon, near kelloggi Merriam
  Aelurodon, sp.
  Canis? davisi Merriam
  Ursus?, sp.
  Mustela furlongi Merriam
  Mustelid, indet.
  Taxidea nevadensis Butterworth
  Pseudaelurus, sp.
  Felis, sp. *a*
  Felis, sp. *b*
Rodentia
  Arctomys nevadensis Kellogg
  Arctomys minor Kellogg
  Citellus, sp.
  Aplodontia alexandrae Furlong
  Mylagaulus monodon (Cope)
  Dipoides, sp.
  Dipoides lecontei (Merriam)

[11] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 199–304, pls. 32–33, 1911; also Butterworth, E. M., Univ. Calif. Publ. Bull. Dept. Geol., vol. 10, pp. 21–24, 1916.

> Entoptychus minimus Kellogg
> Peromyscus antiquus Kellogg
> Peromyscus?, sp.
> Diprionomys parvus Kellogg
> Diprionomys magnus Kellogg
> Hypolagus vetus (Kellogg)
> Ungulata
> Pliohippus, near fairbanksi Merriam
> Hipparion, near occidentale Leidy
> Neohipparion leptode Merriam
> Teleoceras, near fossiger (Cope)
> Mastodon (Tetrabelodon?), sp.
> Pliauchenia?, sp.
> Camel, cf. Camelus americanus Wortman
> Prosthennops?, sp.
> Large suilline form
> Sphenophalos nevadanus Merriam
> Ilingoceros alexandrae Merriam
> Ilingoceros schizoceras Merriam

The Thousand Creek fauna is characterized by the presence of numerous antelopes, some of which are presumably near the modern prong-horn, *Antilocapra*. Others show superficial resemblance to strepsicerine types of the Old World. The Thousand Creek fauna resembles that of the Rattlesnake in many respects. The horses are similar, and the only representation of the peculiar Thousand Creek antelopes known outside of the typical region are found in the Rattlesnake. The rarity of antelopes in the Rattlesnake may be due to chances of collecting, to difference in habitat, or to somewhat later age of the Thousand Creek beds.

Antelope remains found recently in the Pinole Tuff-Orinda fauna of San Pablo Bay suggest a relationship between the Thousand Creek-Rattlesnake and the Pinole Tuff-Orinda stage.

The *Ricardo fauna* of the Mohave Desert area is found in a formation comprising between 3000 and 5000 feet of sharply deformed strata situated at the eastern foot of the Sierra Nevada Range. The beds in which the fauna occurs consist in a large part of tuffs with desert conglomerates or fanglomerates and other deposits formed on land or in evanescent water bodies. In the thick Ricardo formation a moderate variation of the mammals is noticeable in comparison of different horizons, but the fauna seems to be a unit not divisible into sharply separated stages.

The species known from the Ricardo are as follows:

RICARDO FAUNA

Reptilia
  Testudo, sp.
Carnivora
  Canid, small
  Aelurodon, near wheelerianus, n. sp. *a*
  Aelurodon, n. sp. *b*
  Aelurodon, n. sp. *c*
  Aelurodon? or Tephrocyon, sp.
  Ischyrosmilus osborni, n. gen. and sp
  Felid, large
  Felid, small, not Ischyrosmilus
  Mustela buwaldi, n. sp.
Rodentia
  Lepus?, sp.
Equidae
  Hipparion mohavense Merriam
  Hipparion mohavense callodonte Merriam
  Pliohippus tantalus Merriam
  Pliohippus fairbanksi Merriam
  Pliohippus, near mirabilis (Leidy)
Proboscidea
  Tetrabelodon?, sp.
Oreodontidae
  Merycochoerus (Pronomotherium) californicus, n. sp.
Camelidae
  Procamelus, sp. *a*
  Procamelus, sp. *b*
  Pliauchenia, sp.
  Alticamelus?, sp.
Bovidae
  Merycodus, near necatus Leidy

In contrast with other Pacific Coast and Great Basin faunas the Ricardo is characterized by the presence of hipparions of an Old World type with *Pliohippus*, *Merycodus*, and an advanced oreodont near *Pronomotherium*. The Ricardo is in every respect a less advanced fauna than the Idaho. It is distinguished from the Thousand Creek-Rattlesnake stage by the presence of *Merycodus*, and an oreodont; by the presence of hipparions with round proto-cone rather than the *Neohipparion* type with flat protocone; and by absence of highly specialized antelopes and of rhinoceroses. The

presence of such ancient types as *Merycodus* and an oreodont in the Ricardo indicates an earlier stage than Thousand Creek-Rattlesnake from which these types are absent. It is, moreover, possible that the Thousand Creek antelopes are descendants of the Ricardo *Merycodus*. Geologic evidence tending to support the age determination based upon palaeontologic data is found in the greater degree of induration and deformation of the Ricardo.

The *Idaho beds* of Idaho were named by E. D. Cope,[12] who described from them a considerable series of fishes. Beds referred to the Idaho extend over a large area bordering the Snake River Valley in southwestern Idaho, and presumably reach into southeastern Oregon. They are several hundred feet in thickness and exhibit a slight degree of deformation at certain localities. The beds are generally unconsolidated, but may show considerable induration and form steep cliffs. Lindgren[13] collected a mammalian fauna from exposures presumed to be of the same age as the Idaho of Cope. The remains obtained by Lindgren were determined as Pliocene by F. A. Lucas. In the summer of 1916 collections were made at a number of localities in this region by J. C. Merriam and J. P. Buwalda for the United States Geological Survey.

The fauna reported from beds referred to the Idaho formation is as follows:

FAUNA REFERRED TO IDAHO

Equus idahoensis, n. sp.
Equus excelsus? Leidy
Protohippus?
Rhinoceros, probably Aphelops (Teleoceras) fossiger (Cope)
Mastodon mirificus Leidy
Procamelus, size of P. major (Leidy)
Cervus, possibly new, slightly smaller and more slender than C. canadensis (Erxleben)
Horn-core of true antelope (Tragocerus?)
Ischyrosmilus, n. sp.
Morotherium leptonyx Marsh
Castor, possibly n. sp.
Olor, size of O. palaeocygnus
Graculus idahoensis Marsh

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[12] Cope, E. D., Proc. Amer. Philos. Soc., Nov., 1870, pp. 538–547; also Proc. Acad. Nat. Sci. Phila., p. 125, June 26, 1883.
[13] Lindgren, W., 20th Ann. Rep. U. S. Geol. Surv., pt. 3, p. 99, 1900.

The Idaho formation is not as yet satisfactorily separated from the Payette Eocene or Miocene, and from a Miocene or Pliocene stage which may intervene between the Payette and the Idaho. It is, however, quite certain that there exists over a large area of southwestern Idaho a formation several hundred feet thick which may show evidence of deformation, and which contains a fauna of a stage representing either the latest Pliocene or the earliest Pleistocene.

Mammalian remains presumed to represent the Idaho have been reported from a number of localities of which the relative geologic position is uncertain. One might assume from the composition of the entire list of forms obtained by Lindgren that the collections are in the main from beds of Pliocene age, with the possibility that some of the elements are derived from Pleistocene deposits, and possibly some from horizons older than typical Idaho.

Of the several mammalian types listed by Lindgren, the horses are undoubtedly the most important for palaeontologic determination of age. The only form specifically determined in the earlier collections was one considered by Leidy to represent *Equus excelsus*. This species is not known from beds older than Pleistocene. Bones from near Sommercamp Ranch, in the northern portion of the Silver City quadrangle, have been referred to *Protohippus*. If this determination is correct, these beds might be Pliocene or late Miocene. Horse remains obtained at Idaho localities by Buwalda and Merriam in 1916, in the course of investigations carried on for the United States Geological Survey, are of a type clearly to be referred to *Equus*. In the lowest beds examined at a locality on the Snake River, southwest of the town of Caldwell, the bottom of the section furnished material representing a very advanced equine form not distinguished from *Equus* on the basis of size or of advance in specialization of feet and teeth. This species does not seem to the writer specifically identical with any thus far described in America. It differs from the *Pliohippus proversus* type of the upper Etchegoin Pliocene in the typical equine character of the upper cheek-teeth, as shown by the inner wall of the protocone, the fossettes, and the outer walls of the paracone and metacone; so that it must be included within the genus *Equus*. On the other hand, it differs from the described Pleistocene forms of *Equus* in the shorter protocone, which approaches the type of pillar in *Equus stenonis* of the Old World Pliocene.

A rhinoceros from exposures considered as Idaho, east of Boise, was referred to *Aphelops* (*Teleoceras*) *fossiger*. This form represents the late Miocene or Pliocene. *Mastodon mirificus* determined by Leidy from a specimen obtained by Clarence King on Sinker Creek is a Pliocene type. The remains of *Procamelus* might be Miocene or Pliocene. Horn-cores of antelopes, obtained with rhinoceros material near Boise, represent a Tragocerus-like type known in America only from beds of Pliocene age. *Castor* is known from the upper Etchegoin of the western border of the San Joaquin Valley in California. A very large machaerodont cat found in an Idaho exposure on the Snake River southwest of Caldwell belongs to a type nearest to *Ischyrosmilus*, presumed to represent the Tulare stage in California.

With our available knowledge of the mammalian fauna of the Idaho, determination of this formation as Pliocene is apparently supported, but beds both older and younger than Pliocene may be included in the localities from which material has been secured. It is highly desirable to have careful collecting work carried on by trained investigators in the bad-land deposits over the entire area presumed to represent the Idaho formation.

Compared with other faunal assemblages referred to the Pliocene of the Great Basin province, the Idaho fauna of the best known locality in the Snake River region exhibits a relatively advanced stage. The horses find their nearest relatives in the Pleistocene and in the Pliohippus proversus zone of the Upper Etchegoin Pliocene. The deer of the Idaho are possibly related to those of the Upper Etchegoin. The cat is nearest to the ?Tulare *Ischyrosmilus*. The Idaho stage is evidently later than any other described Pliocene faunal zone of the Great Basin province.

The Pliocene faunas of the Great Basin region clearly represent at least three quite distinct stages: the Ricardo, the Rattlesnake and Thousand Creek, and the Idaho. The Ricardo fauna, including as it does *Merycodus*, an oreodont, and several other forms of middle Cenozoic type, is certainly older than the Thousand Creek, Rattlesnake, and Idaho, in which these forms do not appear.

The Thousand Creek and Rattlesnake are evidently of approximately the same stage. In neither fauna is *Merycodus* represented, and no oreodont remains are known. The antilopine type represented by *Merycodus* in the Ricardo is expressed in various forms of

Sphenophalos and *Ilingoceros*. The hipparions of the Rattlesnake and Thousand Creek are apparently a more advanced stage than those of Ricardo, and incline toward the *Neohipparion* rather than the *Hipparion* type.

If, as seems necessary, the Idaho fauna be included in the Pliocene, it must be considered as representing a much later epoch than any of the other Great Basin stages. The presence of *Equus* and *Cervus* and the absence of *Pliohippus* indicate a stage verging on the Pleistocene.

The three Pliocene stages of the Great Basin province may be arranged as follows:

Idaho..............................Equus-Cervus? zone
Thousand Creek-Rattlesnake.........Sphenophalos-Neohipparion zone
Ricardo...........................Hipparion-Merycodus zone

Great Plains Province

In the Tertiary deposits of the Great Plains region a much larger representation of the Pliocene mammal fauna is found than has been thus far secured in the provinces west of the Rocky Mountains. Two or three occurrences of unusual importance are known and at least two faunal stages are distinguished.

The *Blanco fauna* described by Cope[14] from Texas is the most advanced of the well known Great Plains faunas, and the stratigraphic relations of the beds so far as known indicate Pliocene age.

The list of forms in the Blanco fauna is as follows:

BLANCO FAUNA

Carnivora
  Borophagus diversidens Cope
  ?Amphicyon, sp.
  Canimartes cumminsi Cope
  Felis hillanus Cope
Edentata
  Glyptotherium texanum Osborn
  Megalonyx leptostomus Cope
Proboscidea
  Trilophodon? (Gomphotherium) shepardii Leidy
  Dibelodon (Stegodon) mirificus Leidy
  ?Dibelodon tropicus Cope

[14] Cope, E. D., A preliminary report on the vertebrate palaeontology of the Llano Estacado, 4th Ann. Rep. Texas Geol. Surv., 136 pp., 23 pls., 1893.

?Dibelodon praecursor Cope
?Dibelodon humboldtii (Cuvier)
Equidae
    Pliohippus simplicidens (Cope)
    Protohippus?, minutus (Cope)
    Pliohippus cumminsii (Cope)
    Neohipparion, sp.
Dicotylidae
    Platygonus bicalcaratus Cope
    Platygonus texanus Gidley
Camelidae
    Pliauchenia spatula Cope
    Pliauchenia, sp.

Characteristic of the Blanco is the presence of advanced horses of the most progressive type of *Pliohippus* with *Neohipparion*, of advanced mastodontine types near *Stegodon*, of very advanced dogs of the *Borophagus* type, and of two types of edentates. This fauna is also characterized by absence of oreodonts and rhinoceroses.

Most important of all Pliocene mammal assemblages of America is the *Snake Creek* fauna[15] of western Nebraska obtained from beds considered to represent a part of the Ogallalla formation of Darton. From this formation over seventy species are known at present and the wealth of material leads one to hope that the number may be further increased by future collecting.

The varied fauna of Snake Creek may be listed as follows:

SNAKE CREEK FAUNA

Dogs
    Amphicyon amnicola Matthew and Cook
    Amphicyon, sp. indet.
    ?Amphicyon, sp. indesc.
    Aelurodon haydeni validus Matthew and Cook
    Aelurodon saevus secundus Matthew and Cook
    Aelurodon, cf. wheelerianus Cope
    Aelurodon, sp. div. indet.
    Tephrocyon hippophagus Matthew and Cook
    Tephrocyon, cf. temerarius Leidy
    Canis, cf. vafer Leidy
    Tephrocyon mortifer Cook

[15] Matthew, W. D., and Cook, H. J., Bull. Amer. Mus. Nat. Hist., vol. 26, pp. 361–414, 1909; Sinclair, W. J., Additions to the fauna of the Lower Pliocene Snake Creek Beds (results of the Princeton University 1914 expedition to Nebraska), Proc. Amer. Philos. Soc., vol. 54, pp. 73–95, 1915.

Tephrocyon, sp. maj.
?Cyon, sp.
Civet-cat
Bassariscus antiquus Matthew and Cook
Mustelines
Brachypsalis pachycephalus Cope
Brachypsalis obliquidens Sinclair
Martes glareae Sinclair
Cats
Pseudaelurus, near intrepidus Leidy
Cat, non-machaerodont
Machaerodont cat, gen. indet.
?Felis, cf. maximus Scott and Osborn
Rodents
Mylagaulus, cf. monodon (Cope)
Dipoides curtus Matthew and Cook
Dipoides tortus (Leidy)
Hystricops, cf. venustus Leidy
Geomys, cf. bisulcatus Marsh
Edentates
Megalonychid, gen. et sp. indet.
Rhinoceroses
Teleoceras, sp.
Aphelops, sp.
?Caenopus, sp.
Horses
Archaeohippus, sp.
Parahippus, cf. cognatus Leidy
Hypohippus, cf. affinis Leidy
Hypohippus, sp.
Merychippus, cf. insignis Leidy
Merychippus, close to calamarius (Cope)
Hipparion, cf. occidentale Leidy
Hipparion gratum Leidy
Hipparion, cf. affine Leidy
Protohippus, cf. placidus Leidy
Protohippus, near perditus Leidy
Pliohippus, cf. mirabilis (Leidy)
Pliohippus, sp. div.
Peccaries
Prosthennops, cf. crassigenis Gidley
Prosthennops, sp.
Oreodonts
Merychyus (Metoreodon) relictus Matthew and Cook
Merychyus (Metoreodon) profectus Matthew and Cook
Merychyus (Metoreodon), sp.
Pronomotherium siouense Sinclair

Camels
  Protolabis princetonianus Sinclair
  Pliauchenia (Megatylopus) gigas Matthew and Cook
  Alticamelus procerus Matthew and Cook
  Alticamelus, sp. div.
  ?Procamelus, sp. div.
Antelopes and deer
  Dromomeryx whitfordi Sinclair
  Drepanomeryx falciformis Sinclair
  Cervus, sp.
  Blastomeryx elegans Matthew and Cook
  Blastomeryx, cf. wellsi Matthew
  Merycodus necatus sabulonis Matthew and Cook
  Merycodus, cf. necatus Leidy
  Merycodus, sp. div.
Bovids
  Neotragocerus improvisus Matthew and Cook
  Bovid, gen. indet.
  Bison, sp.
Mastodons
  Gomphotherium, sp.
  ?Mastodon, sp.
Birds
  Aquila dananus? Marsh
  Buteo, near borealis (Gmelin)
Reptiles
  Crocodile vertebra
  Lizard jaws
  Huge land tortoise
Of uncertain position
  Part of large mammal jaw

The Snake Creek fauna is characterized by the presence of advanced types of *Pliohippus*, *Neohipparion*, antelopes of the *Tragocerus* type, *Aelurodon*, and a rare edentate. From Snake Creek are also obtained less advanced forms as *Protohippus*, *Merychippus*, *Aphelops*, *Dromomeryx*, *Blastomyeryx*, *Merycodus*, two or more oreodonts, and *Tephrocyon*. The stage of the most progressive horses approaches that of the Blanco forms, while abundant material represents *Merychippus* types nearly identical with those of the Upper Miocene.

The fauna as a whole seems older than the Blanco. If it should ever appear to be divisible into several horizons, one stage may be found near that of the Thousand Creek and somewhat older than

Blanco.   Another stage might be near the boundary line between Miocene and Pliocene.

The *Republican River* fauna of northwestern Kansas, which is often tentatively referred to the lowest Pliocene, is an important assemblage of forms evidently older than the Snake Creek and containing a number of rather characteristic Miocene types.   The faunal list is as follows:[16]

REPUBLICAN RIVER FAUNA

Aelurodon saevus (Leidy)
Aelurodon wheelerianus (Cope)
Dinocyon maeandrinus Hatcher
"Machaerodus" catocopis Cope
?Machaerodus crassidens Cragin
Cynomys, sp.
Dipoides tortus (Leidy)
Mylagaulus sesquipedalis Cope
Mylagaulus monodon Cope
Epigaulus hatcheri Gidley
Lepus, sp.
Tetralophodon euhypodon (Cope)
Tetralophodon campester (Cope)
Teleoceras fossiger (Cope)

Peraceras superciliosus Cope
?Aphelops malacorhinus Cope
Hypohippus, sp.
Protohippus profectus Cope
?Neohipparion retrusum (Cope)
Prosthennops serus (Cope)
?Merycochoerus, sp.
?Merychyus, sp.
?Procamelus prehensilis (Cope)
Procamelus, sp. div.
Pliauchenia minima Wortman
Pliauchenia, sp. max
Merycodus, sp.

The presence in the Republican River of *Mylagaulus, Aphelops, Merycodus,* and several oreodonts strongly suggests Miocene age. *Aelurodon wheelerianus* is much like the common *Aelurodon* from the Barstow.   Other forms as *Dipoides* and *Neohipparion* are Pliocene types.   Matthew and Cook consider this fauna older than Snake Creek, and it is evidently near the border line between Miocene and Pliocene.

The *Loup River*[17] or *Nebraska formation* of Nebraska contains a fauna which has certain Pliocene types as *Dibelodon* (*Stegodon*) *mirificus,* and possibly *Hipparion,* apparently of the same horizon with *Equus* and *Elephas.*   This assemblage represents a stage near that of the Idaho or Tulare, or perhaps somewhat later.   More information is necessary before a judgment as to the composition and age of this fauna can be given.

Of the several Great Plains faunas there can be no doubt as to

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[16] Adapted from Osborn, H. F., and Matthew, W. D., U. S. Geol. Surv. Bull. 361, pp. 115–118, 1909.

[17] Leidy, J., Extinct Mammalian Fauna of Dakota and Nebraska, pp. 13 and 255, 1869.

relative position of the two elements of largest importance: the Blanco is clearly younger than the Snake Creek. If the Loup River is Pliocene it is evidently younger than the Blanco, and if the Republican River fauna be included in the Pliocene it is older than Snake Creek. The sequence then appears as follows:

??Loup River..............Equus-Elephas zone
Blanco...................Pliohippus simplicidens-Boraphagus zone
Snake Creek..............Hipparion-Tragocerus zone
?Republican River.........Peraceras-Protohippus zone

Atlantic Province

In the region east of the Mississippi, Pliocene mammal remains sufficient to constitute a basis for study are known in the Alachua beds of Florida. The study of the fauna has been difficult because of mixture with remains from other formations. The recent work of Dr. E. H. Sellards[18] has made possible segregation of the Pliocene elements. The list is as follows:

ALACHUA FAUNA

Alachua Clays and Bone Valley

Teleoceras fossiger var. proterus (Leidy)
Aphelops malacorhinus Cope
?Mammut progenium Hay
Mastodon (Trilophodon) floridanus Leidy .
Hipparion ingenuum (Leidy)
Hipparion plicatile Leidy
Hipparion minor Sellards
Procamelus major (Leidy)
Procamelus medius Leidy)
Procamelus minor (Leidy)

Tomistoma americana Sellards
Alligator
Cetacean
Fishes
Odocoileus
Megatherium, sp.
Agriotherium schneideri Sellards
Emys
Crocodile or alligator
Garfish

Dunnellon Formation

Aphelops malacorhinus Cope
Mastodon (Trilophodon) floridanus Leidy
Hipparion, sp. div.
Parahippus, sp.
?Megalonyx, sp.

Ursus, sp.
Felis, sp.
Odocoileus, sp.
Procamelus minor (Leidy)

Newberry, Alachua County, Possibly Pleistocene

Equus littoralis Hay
Odocoileus, sp.

Tapirus terrestris (Linn.)

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[18] Sellards, E. H., Fossil vertebrates from Florida: A new Miocene fauna; New Pliocene species; The Pleistocene fauna, 8th Ann. Rep. Florida Geol. Surv., pp. 79–119, pls. 10–14, 1916.

Time Relations of American Faunas

Comparison of Pacific Coast and Great Basin Pliocene faunas shows that of the four stages in the Pacific Coast province the uppermost, the Tulare or Hyaenognathus zone, is evidently nearest the Idaho or Equus-Cervus? zone of the Great Basin. As yet these two faunas are too imperfectly known to permit satisfactory comparison.

The second or Pliohippus proversus zone of the Pacific Coast upper Etchegoin is a less advanced stage than the Idaho, but the fauna is quite different from that of the Thousand Creek-Rattlesnake stage, and is more advanced. This zone is not as yet known in the Great Basin province.

The Pliohippus coalingensis zone of the Pacific Coast region contains horse types near those of the Rattlesnake-Thousand Creek stage and is of approximately the same age.

The Chanac Hipparion gratum tehonense stage of the Pacific Coast province is nearest to the Ricardo of the Great Basin, but not necessarily identical with it.

The relationship of the Pacific Coast and Great Basin Pliocene sequences is approximately as shown in the table on page 903.

Comparison of the series of Pliocene mammal faunas of the Great Basin-Pacific Coast scale with that of the Great Plains and Atlantic provinces should not be expected to show a large percentage of common specific types, even if the time of deposition be approximately identical, as important physical barriers intervened and specific range would presumably not be much wider in America of the Pliocene than at present.

In a comparison of the Great Plains sequence with that in the provinces west of the Wasatch there is noticeable at once a similarity of the Blanco and Upper Etchegoin horses, and of the Blanco canid of the *Borophagus* type and *Hyaenognathus* presumed to be of Tulare age. There seems good reason for considering the Blanco and Upper Etchegoin faunas as of nearly the same stage. The Tulare, which immediately follows the Upper Etchegoin, may approximate a late stage of the Blanco.

The Snake Creek fauna of western Nebraska contains a considerable number of forms corresponding approximately to those of the Ricardo stage of the Great Basin province. The Snake Creek horses include species of *Pliohippus* and *Hipparion* at least as advanced as those of the Ricardo. The artiodactyls of the Snake Creek include

Merycodus and advanced oreodont forms as in the Ricardo.   With the advanced horses there are, however, noted certain primitive forms as *Merychippus* and *Parahippus*, and with artiodactyls of the *Merycodus* type some advanced antelopes are also represented. If, as seems possible, the Snake Creek fauna represents more than one stage, it is to be presumed that one of the horizons is not far from the stage of the Ricardo.   It is possible that another horizon in the Snake Creek beds might correspond to the stage of the Rattlesnake, Thousand Creek, and Middle Etchegoin.

The Republican River fauna of northwestern Kansas represents a stage recognized as near the beginning of the Pliocene.   Matthew and Cook,[19] who have made a most careful comparison of this assemblage with the Snake Creek, consider that modernization is more apparent in the latter.   The Republican River canid fauna contains only advanced forms of the *Aelurodon* or *Dinocyon* type. The Equidae include *Hypohippus*, *Protohippus*, and *Neohipparion*. Two oreodonts, *Merycochoerus* and *Merychyus*, are present with camels of the genera *Procamelus* and *Pliauchenia*.   *Dromomeryx* and *Blastomeryx* are not represented.   Considering that the two areas discussed are widely separated geographically, it would seem to the writer that the Republican River is not far from the stage of faunal evolution shown by the Ricardo.   If the Ricardo is younger than the Snake Creek, the judgment of Matthew and Cook, suggesting the situation of the Republican River earlier rather than later than the Snake Creek, necessitates placing the Republican River somewhat below the Ricardo.

Relationship between the fauna of the Ricardo and that of the Alachua beds of Florida is suggested especially by similarity of the *Hipparion* species.   The American forms most resembling the Ricardo hipparions are *H. plicatile* and *H. ingenuum* of the Alachua beds and *H. venustum* from Ashley River, South Carolina.   This resemblance may be purely incidental, but possibly indicates a close genetic relationship.   J. W. Gidley[20] has suggested that the Florida hipparions are like those of the true Old World *Hipparion* type with round protocone.   It is possible that the Alachua and Ricardo *Hipparion* forms represent some of the oldest members of this group

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[19] Matthew, W. D., and Cook, H. J., Bull. Amer. Mus. Nat. Hist., vol. 26, p. 368, 1909.

[20] Gidley, J. W., Revision of the Miocene and Pliocene Equidae of North America, Bull. Amer. Mus. Nat. Hist., vol. 23, pp. 905–906, 1907.

in America, these species having survived in the southeast and southwest corners of the continent after the forms with round protocone had disappeared in the middle regions of the continent.

As has been known, there is a marked resemblance between the Alachua fauna and the life of the Republican River and Snake Creek stages. The Alachua appears more advanced than the Republican River and approaches the Snake Creek more closely in the important *Hipparion* elements. The presence of both *Teleoceras* and *Aphelops* in the Alachua indicates affinities with the Miocene. The recently described *Mammut progenium* and *Agriotherium* (*Hyaenarctos*) indicate with considerable definiteness the Pliocene rather than Miocene aspect of the Alachua.

CORRELATION WITH OLD WORLD FAUNAS

Certain elements found in American Pliocene mammal faunas so closely resemble characteristic genera and even species of the Old World that little doubt exists concerning their common origin. Such types as *Hipparion, Teleoceras, Tragocerus, Hyaenarctos, Ischyrosmilus, Pseudaelurus,* and *Dipoides* appear even in similar specific garb at various localities in the Pliocene of America, Asia, and Europe. It is worthy of note that the forms appearing in America and in the Old World are also generally widely spread on each of these two areas, indicating their tendency to range widely. It is also worthy of note that some of these forms have a long antecedent history in one area and appear suddenly in the Pliocene of the adjacent region, while within approximately the same periods other groups originating in the second region extended their range to the first area. These arguments, taken with the facts relating to corresponding amount of organic evolution and corresponding amount of crustal movement in both regions, leave little room for doubt that we have here an unusually well founded case of correlation in which contemporaneity is indicated, at least within the limits of half of a geological period.

There is good reason to believe that the earlier American Pliocene faunas as the Alachua, Snake Creek, Ricardo, Rattlesnake, and Thousand Creek are approximately contemporaneous with Old World faunas of Schansi in China, Dhok Pathan of India, Maragha of Persia, and Pikermi of Greece. It is not yet possible to give an exact comparison of the relative stages of the early Pliocene repre-

APPROXIMATE TIME RELATIONS OF TYPICAL PLIOCENE MAMMAL FAUNAS OF NORTHERN HEMISPHERE

North American Provinces				Old World Occurrences			
Pacific Coast	Great Basin	Great Plains	Atlantic	China	India	Persia	Europe
Tulare / ?Hyaenognathus / ?Ischyrosmilus	Idaho / Equus / Ischyrosmilus / Cervus?	?Loup River / Equus / Elephas			Boulder Conglomerate / Equus / Elephas / Camelus		Val d'Arno / Equus / Elephas
Upper Etchegoin / Plioh. proversus / Cervus?		Blanco / Borophagus / Plioh. simplici-dens			Pinjor / Hipparion / Stegodon		?Montpellier / Hyaenarctos
Middle Etchegoin / Plioh. coalingensis	Thousand Creek–Rattlesnake / Pliohippus / Hipparion / Teleoceras / Ilingoceros / Indarctos	Snake Creek / Pliohippus / Hipparion / Tragocerus			Tatrot / Hipparion / Stegodon		?Casino / Palaeoryx
Lower Etchegoin (Jacalitos) / Chanac / Hipparion / Merycodus / Protohippus	Ricardo / Hipparion / Pliohippus / Merycodus / Oreodont	?Snake Creek / Republican River / Protohippus / Hipparion	Alachua / Hipparion / Teleoceras / Procamelus / Hyaenarctos	Schansi, Honan, etc. / Hipparion / Hypohippus? / Tragocerus / Palaeoreas / Hyaenarctos?	Dhok Pathan / Hipparion / Teleoceras / Strepsicerine antelope	Maragha / Hipparion / Tragocerus / Palaeoreas	Pikermi / Hipparion / Tragocerus / Palaeoreas / Hyaenarctos

sented by these faunas. For the later Pliocene less evidence of contemporaneity of American and Old World faunas is available, but there is good reason for looking carefully into the question of relative stage of the Idaho and the Boulder Conglomerate of India, both possibly in part Pleistocene, and both containing primitive forms of *Equus*.

Future work will largely illuminate the field of investigation covering Pliocene life, upon which we have as yet made only a beginning; and later years of study hold in store much of that unequalled pleasure found in difficult scientific quest, and in the discoveries which so frequently reward intensive investigation.

MAMMALIA

FAUNAS OF NORTHERN NEVADA: VIRGIN VALLEY, THOUSAND CREEK, AND THE McKNIGHT LOCALITY

THE OCCURRENCE OF MIDDLE TERTIARY MAMMAL-BEARING BEDS IN NORTH-WESTERN NEVADA

IN THE summer of 1905 the writer received from Mr. Robert L. Fulton, of Alameda, California, several fragmentary bones and teeth of Miocene mammals, said to have been obtained at Virgin Valley, in northwestern Nevada. Subsequently arrangements were made to visit the locality in company with Professor John A. Reid, of the University of Nevada. Professor Reid very kindly made inquiry as to the location of the beds, but was himself unable to visit the region. In June, 1906, the writer in company with Mr. Felix T. Smith, of the University of California, visited Virgin Valley for the purpose of making a preliminary examination of the field. In reaching the valley we were kindly assisted by the employees of the Miller & Lux Company, and in locating the most fossiliferous exposures we were much indebted to Mr. T. H. McGhee, whose son, Mr. Edward McGhee, was the first person known to have discovered fossil bones in that region.

Virgin Valley is situated in northwestern Nevada, about 15 miles south of the Oregon line and 40 miles from the California line. Virgin Creek, which drains the valley, is a tributary of Thousand Creek, emptying into Thousand Lake, close to the northern border of Nevada. The region about Virgin Valley is semi-arid and is practically treeless. Though no extensive search has been made through the literature, I am not aware that this region has ever been visited by any geological party. A number of explorers have evidently passed near it to the north and to the south.

The valley of Virgin Creek is a basin with a north and south trend, the fossil beds being situated in a trough formed by an older series. The older formation consists largely of tuffs, ashes, and rhyolitic lavas. Superficially it resembles a part of the Clarno Eocene series of the John Day region to the north. On the east side of the syncline, at Thousand Creek Hill, a fine section of these beds is exposed.

Some of the tuffs in the upper part of the series are exceedingly coarse, and pieces of pumice in them are in many instances several inches in diameter. The lower portion of this series was not examined, but the materials seem to be finer toward the base of the section. Beds superficially similar to those on Thousand Creek Hill cut off the southern end of Virgin Valley on the other side of the syncline, beyond the Virgin Ranch. At this point they dip back toward the Thousand Creek Hill to the northeast.

The mammal-bearing Tertiary formation, which is here tentatively designated as the Virgin Valley beds, rests in the basin formed by the older tuffs. Where the lower portion of this formation rests upon the older beds it has been somewhat disturbed, but the amount of disturbance appears, at least in some cases, to be less than that shown by the older series. The inclination of the Virgin Valley beds on the eastern side of the syncline may be largely due to the development of an extensive fault which forms Thousand Creek Hill, and presents a steep escarpment to the east.

The thickness of the Virgin Valley beds is evidently between one thousand and two thousand feet. The larger part of the formation is composed of volcanic ash or tuff showing a variable amount of induration. Characteristic bad land structure has been developed in many places. The formation may be divided somewhat arbitrarily into upper, middle and lower divisions. The lower beds are somewhat harder than the others, and where bad land structure occurs in them very steep faces are frequently produced. These beds show strong contrasts of coloration, varying from white to green or bright red. The middle beds are generally brownish or gray, and weather in gently rounded knolls. The upper beds are usually softer than the others and consist of cream-colored ash.

Mammal remains are quite common in portions of the upper beds, and at a horizon which is apparently in the lower division, though not in its lowest portion. Only a very few fragments of bones were found on the middle division, but plant remains are very abundant at this horizon. Large logs of beautifully petrified wood are present in abundance, and near the middle of this division stems and leaves have accumulated in sufficient quantity to form a thin lignitic deposit.

Judging from the character and occurrence of the fossil remains, large portions of the upper and lower divisions of the formation are

of æolian origin, or have formed in shallow, shifting lakes compar-
able to existing lakes only a few feet in depth, such as are not
uncommon in the eastern Oregon region at the present time.   A
part of the middle division, particularly that portion containing
the lignitic deposit, has evidently formed in or about a body of
water.

The mammalian remains obtained from the lower horizon include
a type near *Chalicotherium* or *Moropus*, two types of horses, two or
more cameloid types, a canid and a number of other forms.   *Chali-
cotherium* is represented by a number of characteristic bones, in-
cluding the peculiar phalangeal elements.   Of the horses one is a
form with short-crowned molar teeth resembling those of the Mio-
cene *Hypohippus*.   The other has short-hypsodont molars and is
evidently in, or close to, the Miocene genus *Merychippus*.   Of the
camels one species is represented by limb bones indicating an
animal of considerable size, and evidently of the *Procamelus* type.
The canid is represented by a second lower molar apparently differ-
ing from any type thus far described from the Tertiaries of the
Pacific Coast region.

The fauna of the upper beds includes a mastodon, a horse, two
camels, a large cat and fragmentary remains probably representing
a rhinoceros.   The mastodon is a species of considerable size, and
is evidently not older than the stage of the Mascall Miocene of the
John Day region.   One of the camels is represented by a metapodial
about as large as that of *Alticamelus* of the lower Loup Fork.   The
cat is known only from a second phalanx indicating a large form
with powerful extremities.

Such paleontological material as is present indicates that the
upper division of the Virgin Valley beds is probably of Miocene age
and not older than the stage of the Mascall Miocene of the John
Day region.   The fauna of the lower horizon, so far as known, is
also evidently Miocene, though it may represent a slightly different
phase.

The fauna of the Virgin Valley beds, particularly of the upper
division, appears in a general way to represent the same period as
the fauna of the ash and tuff formations in Nevada, which have
commonly been recognized as corresponding to the Truckee Mio-
cene.   If such is actually the case, there will apparently be little
reason for correlation of the Truckee with the John Day, as has

commonly been done, since the Virgin Valley beds are near the age of the Mascall beds of Oregon, and the John Day is separated from the Mascall Miocene by the Columbia Lava formation, as also by a considerable unconformity below the Columbia Lava.

As far as I am aware, the beds of the Virgin Valley region offer more material for the study of extinct mammalian faunas than has yet been discovered elsewhere in Nevada. Situated as they are between the typical localities of the Tertiary formations of eastern Oregon and the areas of Truckee Miocene in Nevada, they will probably be the key to the correlation of these formations. The examination of the beds made thus far has necessarily been exceedingly superficial, but it is hoped that the continuation of this work during the next season will put us in a position to make a satisfactory determination of the relative ages of the Oregon and Nevada Tertiary formations.

UNIVERSITY OF CALIFORNIA

THE OCCURRENCE OF STREPSICERINE ANTELOPES IN THE TERTIARY OF NORTHWESTERN NEVADA

CONTENTS

INTRODUCTION

D URING the summer of 1909, a palaeontological expedition was organized and financed by Miss Annie M. Alexander for the purpose of collecting mammalian remains in the Tertiary formations of northwestern Nevada, the collections being presented by Miss Alexander to the University of California. The party worked over the region of Virgin Valley, and Thousand Creek, in which a small collection had been obtained by the writer in 1906[1], and also obtained material at a number of localities not heretofore known. The collections brought together represent a wide range of mammalian forms, of which a considerable percentage are new. Some of the most interesting material, particularly from the point of view of the student of geographic range and origin of faunas, is that representing a number of antelopes of the strepsicerine or twisted-horned type, known at the present time only in Africa. No representatives of these forms have been known heretofore from the Western Hemisphere, though they were present in Eurasia in middle to late Cenozoic time.

Twelve specimens of horn cores were obtained in the beds at Thousand Creek, including a number of quite different types. The range of form may be due in part to variation in age or possibly in

[1] Merriam, J. C., The Occurrence of Middle Tertiary Mammal-Bearing Beds in Northwestern Nevada, Science, n. s., vol. 26, p. 380.

sex, but cannot be attributed entirely to these factors. There appear to be at least two species represented which evidently belong to two quite distinct genera.

ILINGOCEROS[2] ALEXANDRAE, n. gen. and sp.

Type specimen no. 11880, Univ. Calif. Col. Vert. Palae., from late Tertiary beds near Thousand Creek in northern Humboldt County, Nevada. The species is named in honor of Miss Annie M. Alexander, through whose efforts the collections of Tertiary mammals from northwestern Nevada have been obtained and made available for scientific investigation.

Frontals not cavernous at the base of the horn core. Horn cores, situated upon the upper posterior region of the orbits, sloping backward, slightly outward, and tilted upward at an angle of approximately twenty-five degrees from the plane of the frontals above the orbits. Horn cores tending to be circular in cross-section excepting for the presence of two or more well-developed spiral ridges. Principal spiral ridge arising above the postero-superior region of the orbit and swinging backward around the axis at the rate of about one turn in three and one-half inches. Posterior to a ·strong groove behind the principal ridge a second spiral elevation may be present, and a third may be present in some specimens referred to this genus. Supraorbital foramina present at the anterior side of the base of the horn cores.

The type specimen (figs. 1 and 4) consists of the basal portion of a left horn, with a part of the frontal forming the superior portion of the orbit and the brain case.

The frontal region, exclusive of the horn cores, so far as represented on any of the specimens, is almost flat anterior to the base of the horns (fig. 3), and the space between the horns is perfectly even, or without a median ridge. Behind a line connecting the anterior sides of the bases of the horns the frontals slope backward and downward from the frontal plane anterior to the horns at an angle of about sixty degrees. On those specimens showing the portion of the frontal above the orbits the supraorbital foramina (fig. 3) are situated a little behind the middle of the superior side of the orbit, and just in front of the middle of the base of the horn core. They vary from round to long-elliptical in form.

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[2] ἴλιγγος, a whirlwind; κέρας, horn.

The horn arises immediately above the upper posterior region of the orbit (fig. 4), and the middle of its basal portion is situated almost immediately over the postorbital process of the frontal. It slopes backward and slightly outward with a sufficient upward
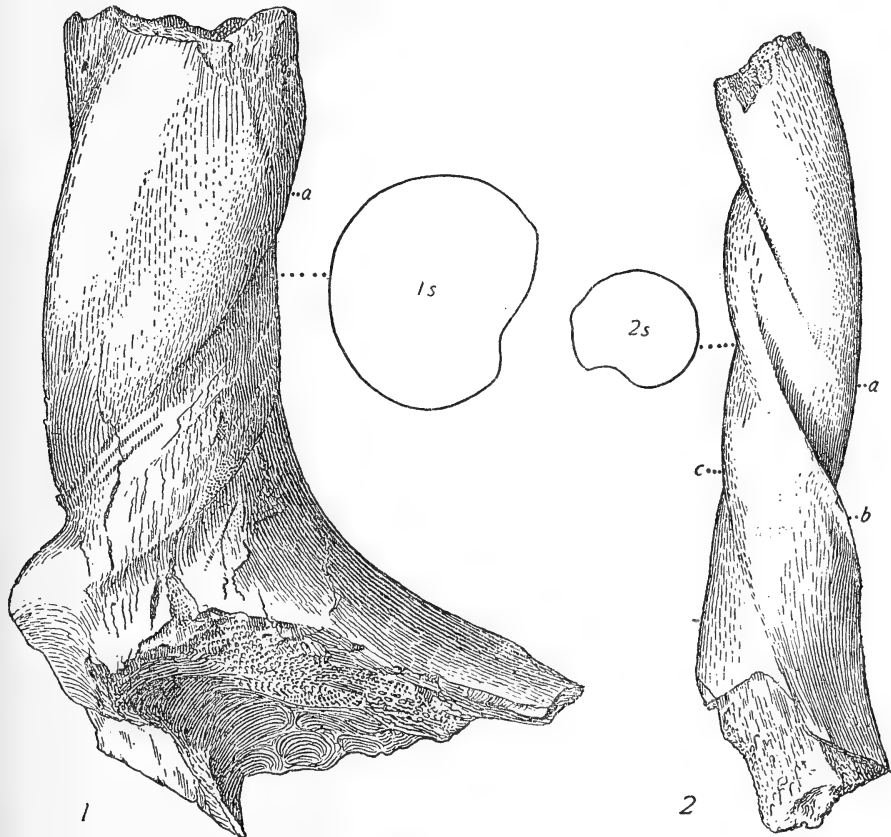

Fig. 1. *Ilingoceros alexandrae.* Posterior view of base of left horn core; *a*, spiral ridge arising over the postero-superior region of the orbit; *1s*, cross-section of horn core. No. 11880, type specimen, natural size.

Fig. 2. *Ilingoceros*, form B. Posterior to postero-median view of basal portion of right horn core; *a*, anterior spiral ridge probably corresponding to ridge *a* in figure 1; *b*, median or lateral spiral ridge; *c*, posterior spiral ridge; *2s*, cross-section of horn core. No. 11892, natural size.

tilt to make an angle of approximately twenty-five degrees with the plane of the frontal above the orbits. In the type specimen a low, rounded ridge which arises from the portion of the horn core base nearest the orbit swings backward over the outer side of the horn,

twisting around it at the rate of one complete turn in about three and one-half inches. This ridge grows much stronger as it approaches the posterior side of the horn. In the type specimen it is accompanied by a groove which arises just above the postorbital process of the frontal. A second ridge rises behind this groove so that two distinct spiral ridges are present (fig. 1).

Excepting the notch formed by the groove between the two principal ridges, the cross-section of the horn core in the type specimen tends to be approximately circular, as it is also in a fragment of a horn (no. 11886) quite certainly referable to this species. Judging from the nearly uniform width at the two ends of all of the fragments seen, the horns did not taper rapidly, and tended to be considerably elongated.

The surface of the horn core is comparatively smooth, with almost no pits or roughnesses. The texture is solid, and not spongy
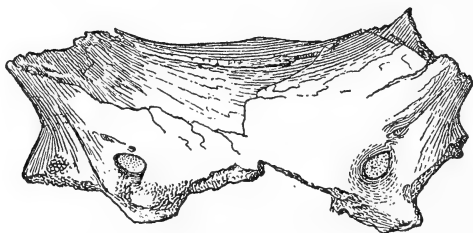
Fig. 3. *Ilingoceros*, sp. Frontal region with bases of horn cores. No. 11882. × ½

as in the true bovine forms. On none of the specimens does there appear to be a distinct line marking the proximal edge of a horny sheath.

In specimen no. 11894 (fig. 5), representing an individual considerably smaller than the type, there is a single strong, acute crest developed, which corresponds to ridge *a* of the type. The general form of the horn is like that of *Ilingoceros*, and it may be referred tentatively to *I. alexandrae*.

In specimen no. 11892 (fig. 2) a horn considerably smaller than the type shows near its base a narrow, sharp ridge with a high, rounded one accompanying it on one side, and a lower one on the other side. The lower accompanying ridge dies out above or unites with the middle one leaving only two prominent ones. Some distance above the base the sharper one becomes less abrupt and
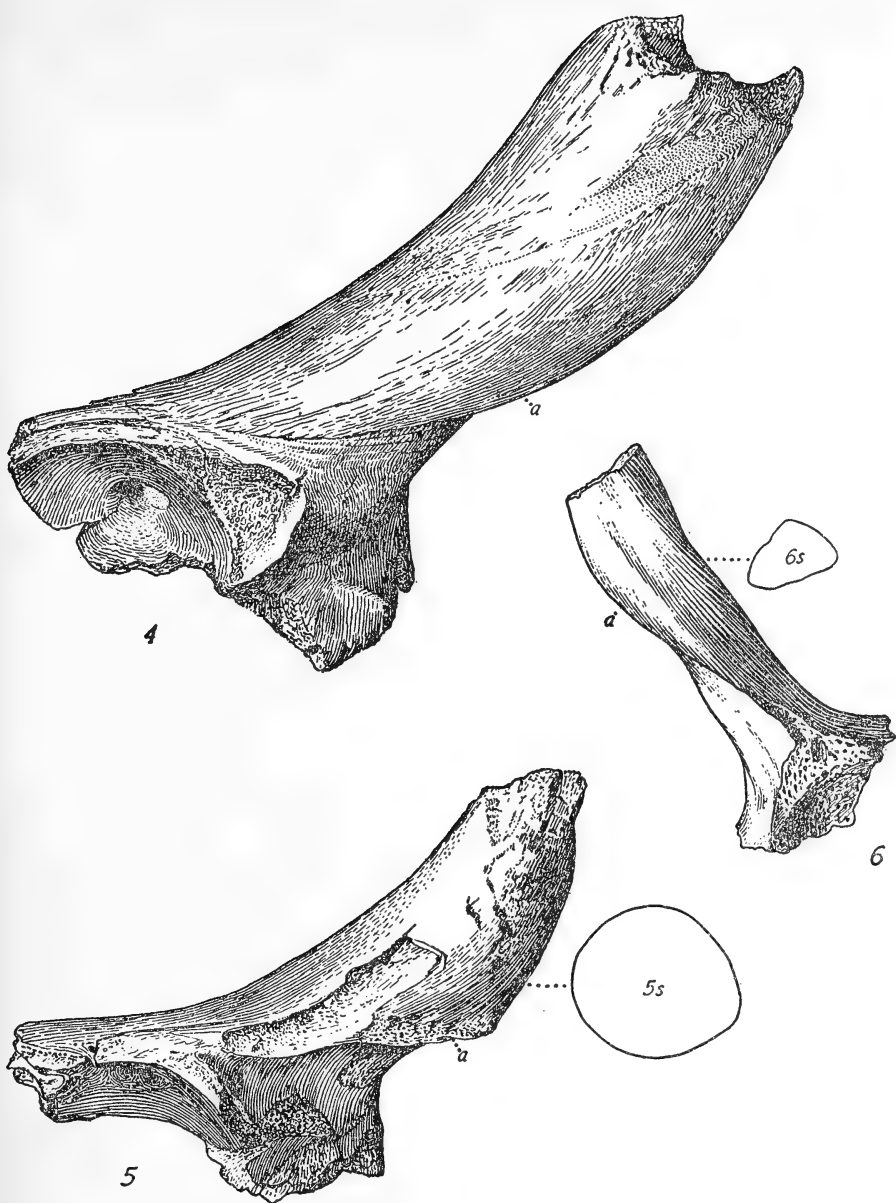
FIG. 4. *Ilingoceros alexandrae.* Outer side of left horn core and orbital region; *a*, spiral ridge originating over postero-superior region of orbit. No. 11880, type specimen, natural size.

FIG. 5. *Ilingoceros alexandrae?* Outer side of left horn core and orbital region; *a*, spiral ridge originating over postero-superior region of orbit; *5s*, cross-section of horn core. No. 11894, natural size.

FIG. 6. *Ilingoceros,* form C. Outer side of right horn core; *a*, spiral ridge originating from postero-superior region of the orbit, and presumably connected with the postorbital process; *6s*, cross-section of horn core. No. 11893, natural size.

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more like the other. The sharp median ridge, called ridge *b* (fig. 2), may correspond to a minor crest that arises from the posterior angle of the postorbital process of the frontal in the type of *I. alexandrae*. The principal spiral ridge arising above the orbit in the type specimen may be called ridge *a* (see figs. 1 and 4). It probably corresponds to the ridge to the right of the median elevation shown in fig. 2. The posterior elevation, ridge *c*, on no. 11892 possibly corresponds to the most posterior elevation arising behind the postorbital process in the type.
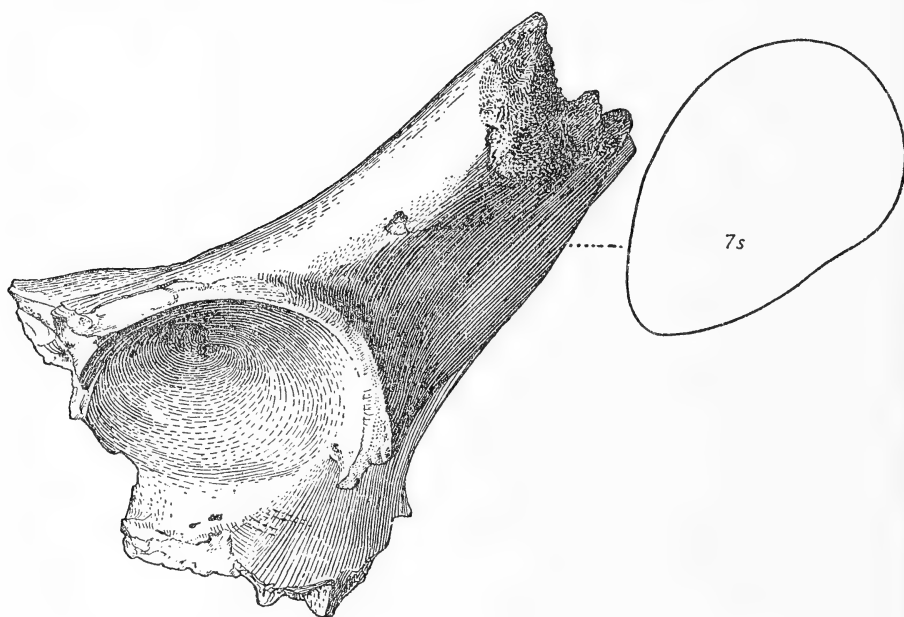
Fig. 7. *Sphenophalos nevadanus.* Outer side of left horn core and orbital region; *7s*, cross-section of horn core. No. 11887, type specimen, $\times \frac{9}{10}$.

Another specimen, no. 11899, seems to be quite certainly of the same type as no. 11892. It belongs to an individual of larger size than no. 11892, but is smaller than the type. These specimens may both represent an earlier stage of development of this species than the type specimen. The fragment, specimen no. 11899, is also probably from a part of the horn core somewhat farther above the base than the uppermost part of the horn core as represented in the type. They may both be referred tentatively to this genus as form B, in contrast with the typical form represented in specimen no. 11880 (figs. 1 and 4).

A very small specimen, no. 11893 (fig. 6), shows a cross-section of the horn core faintly suggesting that of the type of *Sphenophalos nevadanus* described below.   In cross-section at the top the long diameter is a little more than twice the short diameter.   On this specimen two sharply marked ridges arise at the base of the horn core, and come into positions diametrically opposite each other a short distance above the base.   They twist about the core at a rate of about one complete turn in four inches, or at nearly the same rate as in *I. alexandrae*.   As yet we have no definite evidence of a spiral twist of the ridges on the horn core of the type of *S. nevadanus*, though a slight turn outward and backward from the upper region of the orbit is suggested.   This specimen differs from no. 11894 in that the ridge *a*, which seems to rise just outside the superior openings of the supraorbital foramina as in ridge *a* in the type of *Ilingoceros*, appears to be continuous with the posterior angle of the post-orbital process instead of just above it, and may correspond to ridge *b* in no. 11892, form B.   There is farther no suggestion in no. 11894 of a second strong crest opposite ridge *a* as is shown here. From specimen 11892, designated as group B of *Ilingoceros*, this form differs in that the two main crests are near together with a narrow groove between them in group B, while here the main ridges assume positions diametrically opposite each other and the cross-section is narrow.

Specimen 11893 may be referred to *Ilingoceros* tentatively, and designated as form C.

Sphenophalos[3] nevadanus, n. gen. and sp.

Type specimen no. 11887, Univ. Cal. Col. Vert. Palae., from late Tertiary beds near Thousand Creek in northern Humboldt County, Nevada.

Frontals not cavernous at the base of the horns.   Horns situated on the upper posterior region of the orbits, sloping backward, slightly outward, and tilted upward at an angle between twenty-five and thirty degrees from the plane of the frontals above the orbits. Horn cores flattened in a plane extending backward and inward from the orbits.   A short distance above the base the horn cores flare or widen slightly in the direction of greatest diameter in cross-

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[3] σφήν, wedge; φάλος, horn on a Homeric helmet.

section.   Outer anterior edge of the horn core arising over the upper posterior region of the orbit, and swinging backward with a suggestion of a twist.   Surface of the horn core comparatively smooth, with a few pits or irregularities.   Texture of the outer portion of the horn core solid.   Supraorbital foramina present in front of the middle of the antero-medial side of the base of the horn cores.

The type specimen (fig. 7) consists of the basal portion of the left horn with a portion of the frontal extending forward over the orbit, and backward to form a small portion of the brain case.   A second specimen, no. 11888, includes the bases of both horns with portions of the orbits and brain case, and represents an individual a little smaller than the type.

This form differs from the typical *Ilingoceros* in the flattened form of the horn core, which shows only the slightest tendency to twist in the specimens available.   The cross-section of the horn cores is wedge-shaped, the anterior edge being narrower than the posterior.   The antero-external angle of the core rises above the orbit in a line almost parallel with the long axis of the horn, while in the typical specimens of *Ilingoceros* the anterior ridge arising above the postero-superior region of the orbit swings backward sharply across the long axis of the horn and quickly twists around its base.

The posterior aspect of the base of the horn core is also quite different from that of the typical *Ilingoceros*, as a perfectly even surface reaches up from the brain case and extends over the posterior side of the horn core.   In *Ilingoceros* this region is crossed by the sharply twisting spiral ridges (fig. 1).

Systematic Position of Ilingoceros and Sphenophalos

The forms which have been included in the genus *Ilingoceros* as described above seem to belong near the strepsicerine or tragelaphine division of the antelope group.   This sub-family is known at the present day only in the African region, unless, as some writers have held, the peculiar *Boselaphus* of India be grouped with the African forms.   It was represented by several typical twisted-horned types in Europe and Asia in later Tertiary time.   No member of this most specialized group has heretofore been known in the Western Hemisphere.

The type specimen of *Ilingoceros* resembles *Protragelaphus* from the Pliocene of Europe and Asia in some characters, but differs in the position and in the general character of the spiral ridges, in the more erect position of the horns, and in the greater width and flatness of the region between the bases of the horn cores.

The small specimen, no. 11893, tentatively referred to *Ilingoceros* as group C, most nearly approaches *Protragelaphus*, though it is by no means identical with it in form of horn core. A fragmentary specimen, no. 11886, which has been considered as probably representing a portion of a horn core of *I. alexandrae* farther removed from the base than the upper end of the type specimen, suggests the form of the basal region of a horn core from Maragha, Persia, which has been considered by Weithofer[4] as possibly a young individual of *Protragelaphus skouzesi*. It is not improbable that the Maragha form referred to may represent a type distinct from *Protragelaphus*.

The typical *Ilingoceros* differs from *Prostrepsiceros* in the position and form of the spiral ridges, apparently also in the sharper twist of the spiral, and in the wider space between the bases of the horns.

In *Palaeoreas* the anterior spiral ridge rises higher up on the base of the horn than in *Ilingoceros* and is much nearer the median line of the skull, so that the general aspect of the horn is quite different from all points of view.

The specimens included in the genus *Sphenophalos* resemble *Ilingoceros* and the tragelaphine division of the antelopes in the absence of cavities at the base of the horn cores, as also in the density of the horn core as a whole. In the specimens available the horns are much flattened laterally, and have evidently not developed a series of spiral ridges like those of *Ilingoceros*, or the typical strepsicerine forms. The nature of the frontal region does not differ greatly from that of *Ilingoceros*.

Sphenophalos resembles the existing prong-horn antelopes somewhat in the general form of the horn core, and probably also in the character of the surface of the core. The horn cores of *Sphenophalos* differ from those of *Antilocapra* in their relatively greater thickness, and in their more oblique position with reference to the long axis of the skull. They also occupy a slightly more posterior position

[4] Weithofer, K. A., Denksch. d. k. Acad. d. Wiss. Math. Naturwiss. Cl., Bd. 57, Taf. 5, Fig. 2.

with reference to the orbit and are directed backward, instead of standing erect as in *Antilocapra*. The posterior side of the base of the horn core in *Sphenophalos* presents a broad, flat, gently-curving surface, entirely different from the narrow, prominent posterior edge of the base of the horn core in the prong-horn. There is also a noticeable difference in the slope of the roof of the skull behind the horns, this region dropping away from the plane of the forehead more sharply in *Sphenophalos* than in *Antilocapra*.

The resemblance to the prong-horns which is shown in the horn cores of *Sphenophalos* will mean very little if the horns of *Sphenophalos* be found to be of the long, slender type of the true antelopes. The only suggestion that they may have been relatively short is given in the slight tendency of the horns to flare a short distance above the base. It is hoped that later finds may furnish material which will make possible a determination of the entire outline of the horn core.

With the fragmentary material available it is probably not desirable to attempt the definite reference of *Sphenophalos* to any of the existing subdivisions of the antelopes, although it appears to be not far removed from the tragelaphine forms of the Thousand Creek fauna.

The collections from the Tertiary beds of the region of Virgin Valley and Thousand Creek have been as yet only partially examined, and in the present communication only the horn cores have been described, as they seem for the present to constitute the most satisfactory basis for comparison. No reference has been made to a number of specimens representing dentition and general skeletal structure, as the scattered and fragmentary nature of the material is such that only a most careful study will make a correlation of the parts possible. It is probable that a more exhaustive study of the collection will considerably increase our knowledge of these forms, as the dentition of the antelopes has been well described, and made available for comparison by Schlosser.[5]

Related Forms in America

With the exception of the rupicaprine or chamois group as represented by the mountain goats, the true antelopes which are so

[5] Schlosser, M., Abh. Mat. Ph. Cl. k. Bay. Akad. d. Wis., Bd. 22, p. 161.

wonderfully represented in the Old World have not until recently been known to have been present at any time in the fauna of the New World.

In an important paper on "A Pliocene Fauna from Western Nebraska" Dr. W. D. Matthew and Mr. Harold Cook have recently described[6] a most interesting fauna resembling that from Thousand Creek, Nevada, and containing remains of a form considered by them to represent the tragocerine or hippotragine division of the antelope group, which has hitherto been known only from Europe, Asia, and Africa. The horn is short and straight, with a round-oval cross-section. Its surface resembles that of the horns of the Bovidae, and differs from the prong-horn antelope in its comparatively coarse pitted structure.

There is in the University collections a fragmentary specimen from Thousand Creek representing a small portion of a horn core which corresponds very closely in form to about one-third of the horn core of the type specimen *Neotragocerus improvisus* as figured by Matthew and Cook. The cross-section of the horn core is approximately circular and there is no evidence of the presence of spiral ridges. The core narrows rather sharply toward one end, which presumably indicates that the horn was short. It appears to narrow too rapidly to represent simply the tip of a tragelaphine horn. As nearly as can be judged from this specimen there is good reason to think that it is either a form near *Neotragocerus*, or is an early representative of the *Aplocerus* or mountain goat type.

Associated with the antelopes from Thousand Creek there are a number of representatives of the *Merycodus* type, and with these there is one specimen which resembles *Merycodus*, and also suggests *Sphenophalos*. If the lowest beds of the Virgin Valley formation are found to contain these forms, it might be profitable to consider carefully the possibilities of American origin of some of the antelopes here described. It may also be profitable to consider the relationship of the existing American antelopes or antelocaprines to some of the forms represented in this fauna.

Issued December 16, 1909

[6] Bull. Amer. Mus. Nat. Hist., vol. 26, pp. 361–414.

TERTIARY MAMMAL BEDS OF VIRGIN VALLEY AND THOUSAND CREEK IN NORTH-WESTERN NEVADA

PART I. GEOLOGIC HISTORY

CONTENTS

INTRODUCTION

THE Tertiary fossil beds of northwestern Nevada were first brought to the writer's attention in 1905 through Mr. Robert L. Fulton, who kindly permitted the examination of several fragments of bones and teeth obtained in Virgin Valley by Mr. Allan C. Bragg, and given by him to Mr. Fulton. In the attempt to obtain information regarding the geology of the region, the late John A. Reid, then Professor at the University of Nevada, assisted in every possible way.

In June, 1906, the writer, in company with Felix T. Smith, a student at the University of California, made a reconnaissance of the

Virgin Valley region and obtained a small collection of fossils. In a brief statement of the results of this study published by the writer[1] the formation in Virgin Valley was designated as the Virgin Valley Beds. It was considered as Miocene, with the suggestion that the upper part of the series was probably not older than the Mascall stage of the John Day region.

In a discussion of some of the ungulate material collected largely in the older beds at Virgin Valley by Merriam and Smith in 1906, J. W. Gidley[2] expressed the opinion that all of the specimens in the collection examined represented middle or lower Miocene, and that they might be somewhat older than the Mascall.

In the summer of 1909, Miss Annie M. Alexander very kindly offered to organize and finance an expedition to Virgin Valley to carry on the work which had been suggested by the reconnaissance in 1906. The party organized by Miss Alexander spent three months in the field, and after working over the exposures at Virgin Valley and Thousand Creek, the exploration was extended to several localities near Soldier Meadows to the south of Virgin Valley, where a number of new exposures of mammal beds were discovered.

The available information relating to the mammal beds of the Virgin Valley and Thousand Creek region is presented in two parts issued separately. The first part includes a general description of the region, a history of investigation carried on there, and a discussion of the geologic history. The second part contains a discussion of the extinct mammalian faunas of these beds, with a consideration of all the accumulated information contributing to an understanding of the age of these faunas and of the formations in which they are found.

ACKNOWLEDGMENTS

[1] Science, n. s., 26, pp. 380–382. Sept. 20, 1907.
[2] Univ. Calif. Publ. Bull. Dept. Geol., 5, p. 242. 1908.

During the field operations E. L. Furlong devoted special attention to the occurrence and distribution of the mammalian remains obtained, and to the nature of the mammal beds. Mr. Furlong also had immediate charge of the fossil collections. A. J. Heindl brought together a representative collection of rock specimens illustrating the principal lithological phases of the formations occurring in the region investigated, and made a series of notes on their occurrence and structure.

In carrying out the work of the expedition the Pacific Live Stock Company, through all of its representatives with whom the members of the party came in contact, most generously assisted in every way possible, and contributed greatly to the efficiency of the expedition. Particularly in connection with the work in the field, mention should be made of assistance by Mr. F. M. Payne, who was very helpful to the party.

The writer is also indebted to T. H. McGhee and Edward McGhee of Virgin Valley for information regarding the occurrence of fossil remains. It should be stated that Edward McGhee is, so far as known to the writer, the first person to discover fossil bones in Virgin Valley. On the reconnaissance trip made by the writer in 1906 T. H. McGhee very kindly indicated to us the situation of some of the most important fossil localities in the region.

General Physical Features of the Region

The region in which the mammal-bearing beds of Virgin Valley and Thousand Creek are situated lies between two fairly defined areas of quite different topographic nature. To the east and south there is a succession of sharply defined mountain ranges with a general north and south trend, between which are broad and remarkably flat valleys. The Pine Forest and Pueblo ranges, which form the eastern border of the region in which the principal field work was carried on, rise to a height of over 9000 feet. The broad valleys have an elevation of about 4000 feet.

As is so frequently shown in the Basin region, the development of the mountain chains to the east of Virgin Valley is evidently due in a large part to faulting. The remarkably even filling of the valleys was accomplished in part by alluvial wash, and partly by accumulation in lakes. A series of terraces distinctly shown bordering the flats near Sodhouse Point and near Mason's Crossing, in the valleys immediately to the east of Pine Forest Range, represents the

shore-line of a body of water which must have covered a large part of the valley floor in this region during some portion of Pleistocene time. Associated with the terraces are remnants of marginal deposits containing a fresh-water molluscan fauna. Along certain levels, the marginal deposits of the ancient lake show an extraordinarily heavy calcareous deposit. According to Russell[3] this region was occupied by the northern extension of Lake Lahontan, and the terrace deposits to which reference has just been made were evidently formed during that period of deposition.

In the region to the west of Virgin Valley the country is largely lava-covered, and is evidently a southward extension of the great lava plateau in the Oregon region to the north. The valleys here are either broad and comparatively shallow depressions, due to crustal movements of less magnitude than those which produced the deep, broad valleys to the east; or they are comparatively narrow cañons due to erosion. The general level of this region is much higher than that of the broad valleys to the east.

The region under consideration may be classified, as a whole, as semi-arid, excepting some of the highest zones of the larger mountain masses. Over the greater part of the area sage-brush is the dominant type of vegetation. Trees are almost entirely absent, excepting scattered junipers on the hills, a few alders and willows along the streams, and a few pines in the highest zone.

Notwithstanding the generally arid nature of the country, there is sufficient grass, and other vegetation which may serve as food for herbivorous animals, to support a large mammalian population. In comparatively recent time the ungulates have been quite abundantly represented by prong-horn antelope, deer, and mountain sheep. At the present day the carnivores are numerously repre sented by coyotes, wild-cats, and badgers, and an abundant rodent population includes many genera and species. The fauna as a whole is surprisingly rich in variety of forms and number of individuals.

Geologic Features of the Region

The geologic features of the region visited by the expedition present a most attractive study. A considerable number of well-defined formations are represented and numerous instructive sec-

[3] Russell, I. C., Lake Lahontan, Monog. U. S. Geol. Surv. no. 11. 1885.

tions are exposed by extensive fault-scarps and deeply eroded cañons. The district immediately surrounding the field examined apparently shows a range of geological systems extending from Palaeozoic to Quaternary.

As the primary object of the expedition was to obtain a representation of the mammalian fauna of the sedimentary formations in the Virgin Valley region, the acquisition of palaeontological material was the occupation of first importance. Investigation of the formations represented has therefore of necessity been confined almost exclusively to the fossil-bearing beds with those adjacent to them, and may not be considered as more than a reconnaissance.

In the region investigated, five fairly distinct geologic sections were examined; *viz.*, those of Pueblo Range, Pine Forest Range, Virgin Valley, Thousand Creek, and High Rock Cañon. For the purpose of description these sections are discussed separately.

Pueblo Range Section

Previous to the brief note published by the writer in 1907[4] the only reference to the geology of the region near Virgin Valley known to have been published is that of Blake[5], in 1875, on the Pueblo Mountains, extending southward along the east side of the Thousand Creek region (pl. 2).

Blake described a section of the beds across the Pueblo Range which corresponds very closely in its upper portion with a profile of the southern extremity of this range made by A. J. Heindl, and confirmed by the independent observations of E. L. Furlong and the writer in passing through this region. According to Blake, the lowest formation is a "porphyry" which is overlain on the east side by "metamorphic rocks, principally micaceous and talcose schists with some metamorphic limestones. These have a dip of about 78° E. with a strike generally North 16° E. They appear to have been thrown up by an eruption of porphyry, which now forms the crest of the ridge." The western portion of the section is formed by a ridge which overlaps the eastern ridge both at its north and south ends. The western ridge was described as "composed entirely of volcanic rocks, arranged in regular strata, with a dip of 20° to the west. They form perfectly conformable layers, and extend

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[4] Science, n. s., 26, p. 380. Sept. 20, 1907.

[5] Blake, J., Proc. Calif. Acad. Sci., 5, pp. 210–214. 1875.

from its base to the summit of the ridge, a height of more than 1200 feet, 6,000 feet above the level of the sea. The beds are composed of many varieties of volcanic rock." The section of the western ridge consisted mainly of basalts below, with trachytic rocks at the top. At the southern end of the ridge Blake observed strata considered as of aqueous origin. "They were laying perfectly conformable on volcanic rocks and were covered in by a layer of gray trachyte also perfectly conformable with these aqueous beds. The beds were about 200 feet thick, consisting of strata of white and red argillaceous rocks, rolled conglomerate, and were all evidently formed from debris of volcanic rocks, the conglomerate being made up principally of rolled pumice."

Blake pointed out particularly that the succession of igneous rocks, in which basalts occurred below trachytes, did not agree with Richthofen's system. He also expressed the view that "the geological formation of this range will be found to be repeated in the vast outflows of volcanic rocks that cover so large a portion of Eastern Oregon, extending north beyond the Columbia River."

No definite evidence of the age of any of the formations was given by Blake, though he suggested that the erupted rocks were early Miocene, and that the older rocks of the eastern ridge were probably Triassic.

Waring[6] in his account of the Geology and Water Resources of the Harney Basin Region, Oregon, refers to the work of Blake and speaks of the Pueblo Mountains as "composed of rocks that belong to an older series than do the lavas to the north. These mountains were only cursorily examined, but from float specimens that were collected along the eastern base of the range they appear to be made up of andesitic porphyries, micaceous schists, and granitic rocks, which have been more or less extensively affected by mineralizing agents."

In Waring's paper on the Harney Lake region, the geology of an extensive area to the north of Virgin Valley and Thousand Creek has been outlined. Unfortunately the geologic mapping was not carried to the southern end of the Harney Valley sheet on Waring's map, but was discontinued about twenty miles north of the Oregon line. The northernmost point reached by the University of Cali-

[6] Waring, Gerald A., U. S. Geol. Surv., Water-Supply Paper, 231, p. 18. 1909.

fornia expedition in 1909 is situated near the southern border of
Oregon.

The section at the southern end of the Pueblo Range was exam-
ined in detail by Heindl in the ridge opposite Mud Lakes. At this
point a thickness of about eleven hundred feet in the upper portion
of the series is exposed by a sharp fault along the west side of the
lake. The beds here dip at an angle of about twenty degrees to the
north of west. The section as obtained by Heindl is shown in
figure 1.

As nearly as can be determined the sequence here agrees with
that observed by Blake.[7]
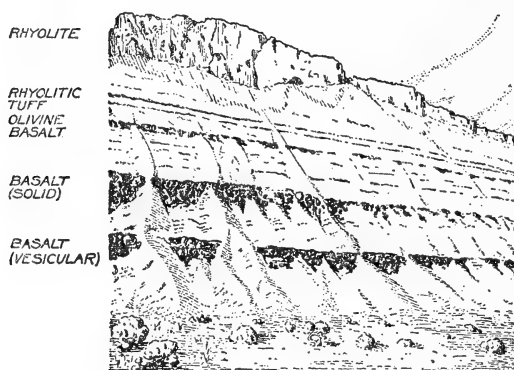
Fig. 1. Cliff section showing a portion of the Pueblo Range Series immediately west of
Mud Lakes.

To the west of this extension of the range there is a considerable
thickness of ashes and tuffs resting upon the beds exposed at Mud
Lakes. Above these ash beds are still later eruptives which Heindl
believes to be rhyolite. This portion of the section presumably
corresponds to the upper portion of Blake's section showing beds
considered to be of aqueous origin. According to Blake the beds of
supposed aqueous origin were conformable with the volcanic rocks
below them, and were covered by a layer of gray trachyte, also
conformable. The sedimentary beds consisted in part of conglom-
erate which was made up largely of rolled pumice.

Seen from some distance to the south, the great series of the
Pueblo Range eruptives and the associated beds appears as a re-

[7] Op. cit. 1875.

markable example of evenly tilted strata, extending back toward the mountain core by regular steps as each hard stratum is passed. The whole series runs under the plain of Thousand Creek to the west with a fairly uniform dip of approximately twenty degrees. In all of the localities in which the mammal beds of Thousand Creek have been observed they are nearly horizontal. Though no observations have been made at their actual contact with the older formation, there would seem to be a strong angular unconformity between the two.

Whether the sedimentary beds in the upper portion of the Pueblo Range section actually belong with the lavas and tuffs below is not certain. They, with the lavas, appear to represent one general period of deposition. At all events they both antedate the period of deformation which preceded the deposition of the Virgin Valley and Thousand Creek beds.

For practical purposes it is desirable to refer to the rhyolites and basalts on the western side of the Pueblo Range, with whatever eruptives or other beds may be shown to belong in the same series, as the Pueblo Range Series, a geographic designation indicating the section first described by Blake. This section is geographically so situated that it should be possible to correlate it with other igneous series in the region of southern Oregon and northern Nevada. To this series the Cañon Rhyolite bordering Virgin Valley apparently belongs, although it is not entirely certain whether it represents exactly the same horizon as the rhyolites exposed in the upper part of the section immediately to the west of Mud Lakes. A careful study may show the Pueblo Range Series to be composed of several fairly distinct divisions.

Pine Forest Range

Corresponding in a manner to the observations of Blake on the Pueblo Range, the work of the University of California expedition has shown that the prominent mountain mass known as the Pine Forest Range (pl. 2) which overlaps the southern end of the Pueblo Range comprises a granitic mass bordered by rock series which have undergone considerable alteration in many cases. On the eastern side of the southern end of the range there are extensive exposures of limestone which appear from a distance as a grayish band running obliquely up the mountain slope from the south. In this exposure

Miss Alexander obtained a considerable number of specimens made up largely of round crinoid stems. Although the crinoid fragments are insufficient evidence upon which to base a definite age determination, the presence of stems of this character probably indicates that the beds are older than the Triassic, as the most abundant Triassic crinoids of this general region are not of the round-stemmed type. The presumption is that the limestones are Carboniferous, though there is no definite evidence that they are not older.

The sides of the Pine Forest Range are flanked by series of igneous rocks that apparently correspond in a large part to the Pueblo Range Series represented by such extensive exposures on the western side of the Pueblo Range immediately to the north.

Virgin Valley Section

The geologic section exposed in Virgin Valley is the most important examined, as the larger part of the known Tertiary history of this region is illustrated here in excellent exposures. At least three formations are represented, of which the middle one is the mammal-bearing series known as the Virgin Valley Beds. The Cañon Rhyolite immediately underlying the mammal beds is presumably of the same age as the upper or rhyolitic portions of the Pueblo Range Series. The Mesa Basalt, which overlies the Virgin Valley Beds, is widely spread over the surrounding region. (See fig. 2.)

The structure of the beds in Virgin Valley is in general synclinal. The basal formation, the Cañon Rhyolite, dips southwest and beneath the valley from Thousand Creek Ridge to the east; and reappears, dipping northeast, in Hard Rock Ridge to the southwest. The Virgin Valley Beds form a shallow trough, but are less distinctly folded than the basal rhyolites. The basalt capping is practically horizontal.

Cañon Rhyolite.—In Virgin Valley, and also at Thousand Creek, the formation underlying the mammal beds consists of rhyolitic flows. In Virgin Valley this basal series is folded into a syncline containing the Virgin Valley Beds. The rhyolites are well exposed on the western side of Virgin Valley at Hard Rock Ridge near Virgin Ranch, where they are dipping gently to the northeast beneath the Virgin Valley Beds. These beds form the sharp gorge through which Virgin Creek enters the valley from the southwest.

To the east, the rhyolites form Thousand Creek Ridge, which slopes gently to the southwest and drops off precipitously to the east (see pls. 3 and 4, and text fig. 2). Through this ridge the drainage of the valley escapes in a deep, narrow cañon cut by Thousand Creek. At Thousand Creek Cañon the rhyolites are exposed to a thickness of not less than four hundred feet and dip gently toward the southwest, or toward the middle of Virgin Valley.

At the top of the hill above Thousand Creek Cañon, the uppermost beds to the south of the wagon road are practically horizontal, and judged from their position possibly represent a phase of the rhyolite laid down after the earlier portion of the formation had been eroded and deformed. From this upper phase much of the rhyolite occurring as pebbles and boulders in the rhyolitic gravels apparently interbedded with the Virgin Valley Beds (see p. 938) seems to have been derived. The rhyolite flows are accom-
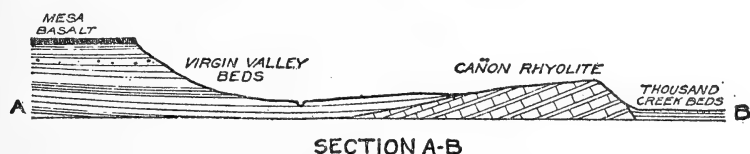
FIG. 2.   Section along A-B line on plate 2, showing section across Virgin Valley and Thousand Creek Ridge.

panied by tuffs, which are exceedingly coarse in places, the fragments of pumice in them being in many cases several inches in diameter.

The precipitous slope on the east side of the rhyolitic outcrop at Thousand Creek Cañon is a fault-scarp, the base of which is covered on the east side by the mammal beds of Thousand Creek. On the eastern side of the Thousand Creek basin the same mammal beds rest upon the rhyolites forming the upper portion of the eruptive series on the northwestern flank of the Pueblo Range.

The rhyolites of Thousand Creek Cañon may be traced around the borders of Virgin Valley to the northwest along the valley of Beet Creek, and seen from a distance they appear to form the sharp gorge at the upper end of Beet Creek (fig. 3, p. 934).

The rhyolites evidently extend south from Thousand Creek to the valley of Gridley Lake, where Heindl found them exposed on the west side of the valley by a fault running northeast and

southwest, in a line nearly continuous with that of the fault west of Mud Lakes to the north. The western flank of Pine Forest Range just to the east of Gridley Lake valley seemed to Heindl to consist of an eruptive series similar to that exposed in the fault-scarp on the west side of the valley.

An outlying mass of rhyolite is also seen in a prominent hill known as Antelope Butte, which rises above the lava-covered mesa south of Virgin Valley (see fig. 4, p. 937).

The rhyolites in these several regions are quite similar petrographically, they are always below the mammal-bearing formations, they have experienced about an equal amount of deformation, and there is evidence indicating that they belong to the series of eruptives flanking the western side of the Pine Forest Range; so that they may all be considered as representing approximately the same horizon. From their occurrence in gorges around the borders of Virgin Valley, these lavas may be known as the Cañon Rhyolite. They are presumably only a portion of the extensive series for which the geographic appellation of Pueblo Range Series is used.

As was shown by Blake[8] the rhyolites of the Pueblo Range are only the uppermost portion of a thick series composed largely of basalts. In his mapping of the formations of southeastern Oregon, Waring[9] has recently shown that the principal series of lavas occurring over this region consists largely of basalts followed in many instances by rhyolites. The rhyolites of the Virgin Valley region are presumably only the upper portion of this extensive formation. As has been stated by both Blake and Waring, there is reason to believe that this series of eruptives is to be correlated with the great lava beds reaching over a very wide extent of territory in the Columbia River region.

As extensive lava formations both older and younger than the Columbia Lava are well known in the great Columbia River area immediately to the north, it is desirable that the eruptive series of southern Oregon should be carefully compared with those of several typical sections where the age and relationships of the lavas have been determined. From the point of view of general geology it is very desirable that an attempt be made to connect the area mapped in southern Oregon with the section of the John Day region, which

[8] Op. cit., p. 214. 1875.
[9] Op. cit. 1909.

is the most satisfactory series of formations for correlation purposes that has yet been observed in this region.

With our present knowledge of the eruptive formations of southern Oregon, there is reason for considering the principal lava series, of which the Pueblo Range Series seems to be representative, as presumably, though not certainly, the correlative of the definite horizon of eruptives situated between the John Day and Mascall formations on the John Day River, at Picture Gorge, near Dayville, Oregon. To this phase of the igneous succession the name Columbia Lava has been definitely limited by the writer[10], as it seemed desirable not to discard entirely the name so appropriately suggested by Russell[11] for the great lava flows of the Columbia River region[12].

Virgin Valley Beds.—Resting upon the Cañon Rhyolite in Virgin Valley is a thick sedimentary series, consisting largely of volcanic ash and tuff, which has been designated as the Virgin Valley Beds[13] (see pl. 5; and text fig. 2, p. 929). It is from this formation that the Tertiary mammalian fauna of Virgin Valley is obtained.

The Virgin Valley Beds have been protected by the overlying Mesa Basalt, which now forms extensive table lands on each side of the valley; and in the escarpments bordering the mesas exceptionally good sections are exposed. Although a considerable fauna has been obtained from these beds, vertebrate remains are nowhere abundant in them, and the collections available represent much painstaking effort.

The thickness of the Virgin Valley Beds, measured from the uppermost strata to the floor of the valley, is about 1500 feet. The beds are evidently thinnest around the edge of the valley, and the bottom of the formation is not reached at the point where the measurements were made. Even taking into account a slight dip of the beds from the highest point toward the lowest level, the total thickness may be estimated at over 1500 feet.

Throughout the whole extent of the valley the strata are found to vary only a few degrees from a horizontal position, excepting through landslides. Such variation from the horizontal as is shown expresses a gentle syncline with the depression near the middle of

[10] Univ. Calif. Publ. Bull. Dept. Geol., 2, p. 303. 1901.
[11] Russell, I. C., U. S. Geol. Surv. Bull. no. 108, p. 20. 1893.
[12] This igneous series has also been known as the Columbia River Lava.
[13] Merriam, J. C., Science, n. s., 26, 1907, p. 380.

the valley.   This is presumably due mainly to a slight deformation which has taken place since the principal accumulation occurred. It may be due in a small part to conformation to the form of the trough in which the beds were laid down.

The Virgin Valley Beds are almost entirely made up of volcanic ash and tuff.   At several horizons gravel, sand, clay, lignite, and diatomaceous deposits occur, but are of much less volume than the beds of purely volcanic origin.

The lowest strata recognized in the valley are ashes and tuffs dipping gently to the west along the western side of Thousand Creek Ridge (pl. 5).   These strata are predominatingly white, but range in color through bright red, purple and green.   This phase is overlain commonly by a series of dark red beds which have quite an extent along the stream bed in the northern part of the valley.

The lowest beds of the series rest upon the irregular surface of the Cañon Rhyolite.   Such evidence as is available suggests uncon-formity between the lower Virgin Valley Beds and the Cañon Rhyolite.

The white ashes of the lowest portion of the section have prob-ably accumulated quickly.   The dark red horizon presumably represents a period of slower accumulation with extreme oxidation. The mode of accumulation of the lowest beds examined is not strongly suggested by any evidence obtained thus far, but they are not improbably aeolian.   The red beds are possibly aeolian.

The section of the formation immediately above the dark red horizon is distinguished by a brownish-yellow coloration over a considerable part of the valley.   The same general horizon is apparently represented by a grayish or buff phase in many places.

In that portion of the section above the red beds, at some locali-ties in the yellow phase and at others either below or above it, there are considerable thicknesses of thinly-bedded, highly carbonaceous shales which may contain numerous lignitic layers (pls. 6 and 7). The shales are largely clay and ash, but may be diatomaceous.   The lignitic seams are very numerous in some of the sections, as on the south side of the valley of Beet Creek.   They have usually a thick-ness of only an inch or two.   Prospecting for coal has been carried on in this portion of the series but no deposits of economic value have yet been discovered.

A number of fossil leaves were obtained in the section on Beet

Creek. It has been found very difficult to transport specimens owing to the friable nature of the rock, and only a few species have been obtained for study.

At one locality of the middle beds in Virgin Valley opal specimens of some commercial value are found. The opals occur largely in cracks or cavities in the typical fossil-bearing beds of this horizon.

The deposits of that portion of the Virgin Valley represented by the yellow beds and the carbonaceous strata were certainly in part laid down in water. The diatomaceous beds are of aqueous origin, and some of the gray clayey strata which are found to contain fish-bones in considerable numbers must also have been formed in water. The shales with numerous lignitic seams are evidently swamp or lake deposits in a large part.

That portion of the Virgin Valley Beds above the yellow and the carbonaceous phase of the formation constitutes the largest part of the series of beds exposed. It is made up almost entirely of white to buff or cream-colored ash and tuff. Some strata are almost pure, sharp-edged ash which has been but little worked over. In other beds, the glass is much decomposed and the material has apparently been worked over considerably. There are in this portion of the section a number of beds of gravel and boulders which are evidently of fluviatile origin, but the impression given by this section as a whole is that it is largely of aeolian origin. This suggestion is also supported by the nature of the fossil remains in these beds, which are those of land forms. This does not preclude the possibility that some of the strata accumulated in temporary lakes.

During the deposition of the Virgin Valley Beds the conditions of accumulation were apparently much as those at the present time in most of the large valleys of the Nevada or eastern Oregon region. The Cañon Rhyolite evidently formed the rim of the valley, while the sediments laid down in it were spread out to form a broad and nearly level floor. Whether the conditions were such as to cause sedimentation in water or in air, the evenness of the stratification remained much the same.

As suggested under the discussion of the later history of this region (see p. 940) there is reason for believing that a considerable thickness of rhyolitic gravels resting unconformably upon the middle beds of the Virgin Valley section in the angle between the valleys

of Virgin Creek and Beet Creek (pl. 8) represents deposition within the Virgin Valley epoch. Whether this unconformity exhibited here is general throughout the Virgin Valley section, or whether it is a purely local feature, is not known. If it should be found to represent a widespread condition of erosion, it would be necessary to divide the Virgin Valley section into an upper and a lower division. In this case, the name Virgin Valley Series may be applied to the whole group of beds between the Cañon Rhyolite and the Mesa Basalt. The beds below the unconformity would then be known as the Lower Virgin Valley Beds, those above the unconformity the Upper Virgin Valley Beds.

Mesa Basalt.—Where they are not uncovered by erosion, the Virgin Valley Beds are capped by an extensive sheet of olivine basalt of a doleritic facies. This capping forms the "rim rock" of the great mesas on both side of the valley of Virgin Creek and may be known as the Mesa Basalt (see pls. 9 and 10, text fig. 2, p. 929, and

FIG. 3.   View of the mesa north of Beet Creek.   See also plates 2 and 10.

text fig. 3). So far as observed, the lava sheet is not distinctly unconformable upon the underlying beds. The table-lands covered with this lava capping are known to extend for a distance of fifteen or twenty miles north and south. As seen from a commanding point above its level, the table-land appears to have an extent several times the length of the section in which the basalt capping has actually been traced, and the presumption is that this flow reaches over a territory much larger than that personally visited. The surface of the basalt cap, and of the mesas in general, is normally nearly level, or with only slight undulations. Several faults of considerable magnitude have developed in the mesa to the northeast of Virgin Valley in the movement of large crustal blocks in comparatively recent time.

To one traveling over the mesas, the surface of the table presents a most unusual spectacle. The lava is only partly covered by irregular patches of soil in which no plants larger than sagebushes have developed. The evenness of the surface and the unvarying

nature of the long stretches of sagebrush and lava blocks are such as to make a judgment of distance most difficult.   Above the surface of the lava there rise here and there a few prominent points (see pl. 10), as Antelope Butte (fig. 4, p. 937) situated on the mesa south of Virgin Valley.   This point consists of a dome of rhyolite which projects as an island rising three hundred feet above the level surface of the basalt flow.

The basalt sheet is near twenty-five feet in thickness over the region where it has been examined, and consists of several fairly distinct layers.   The separate beds observed may not be persistent, and may be nothing more than local advances of a single flow.   The uniformity in thickness is quite remarkable, and evidently indicates that the lava was poured out on a nearly even plain.   Though the dissection of the mesas by erosion has exposed splendid sections of the region formerly covered by the basalt, no dikes or fissures have been observed through which this lava has come to the surface. Such sources may, however, appear in localities not yet visited. The extent of this flow appears rather remarkable when considered in relation to its thinness.   It is difficult to understand how a flow could extend itself so broadly without heaping up more than is indicated in this section.

Taking into consideration the thinness of the flow and the even- ness of the floor upon which the Mesa Basalt was laid down, the present aspect of the table-lands surrounding Virgin Valley may be considered as closely representing the nature of the topography of this region during the latter part of the epoch of deposition of the Virgin Valley Beds.   If the lava sheet were removed, the sedi- mentary beds below would form a nearly level plain reaching well up on the side of the range to the south.   Many of the salient fea- tures of the topography which existed in early Virgin Valley time would be completely buried, while a few of the highest points would project as islands rising sharply above the surrounding ash accu- mulation.

History Subsequent to Outpouring of Mesa Basalt.—No accumula- tion of sediment has been observed to rest upon the Mesa Basalt. Though such formations may possibly exist in localities that were not visited, the impression received in a general survey of the table- land region is that the basalt sheet was the last deposit laid down in the region anterior to the events that initiated the cycle of erosion during which the present valley was excavated.

Movements following the outpouring of the basalt sheet are evidenced in the presence of a sharply-marked fault along the line of the scarp following the east face of Thousand Creek Ridge. The basalt cap to the north of Thousand Creek Cañon is sharply cut off along the extension of the axis of the ridge, the mesa on the east side of the jog dropping a little over four hundred feet below the level of the mesa to the west. This movement is a late phase of the adjustment of crustal blocks which evidently began moving before the deposition of the Virgin Valley Beds. It is not improbable that a small amount of movement occurred along this line during Virgin Valley time. The level of the region to the west of the fault-line must have been somewhat higher than that of the country to the east after the basalt outflow in order to permit the establishment of the present drainage system, which flows toward the east across Thousand Creek Ridge.

The drainage system of Virgin Valley as it now appears is a very interesting feature of the region, as it pursues its course apparently without respect to very prominent barriers (see pl. 2). To the north, west, and east of the valley the streams cut narrow cañons through very hard ridges of the older rhyolitic rocks; while the stream-beds in the valley proper are broad, and in some cases widen out into marshy belts. The small stream of Thousand Creek, formed by the union of Virgin and Beet creeks, leaves the broad, open valley to cut straight into the hard rhyolite of Thousand Creek Ridge, through which it passes in a very narrow cañon (pls. 3 and 4). It is evident that the barriers crossed by the present drainage were passed in the process of cutting through the Virgin Valley Beds and into the buried ridges of the older formation. The general progress of cañon cutting may have been retarded considerably at times by the nature of the opposing barriers, and movements along the fault-line crossing the stream at the mouth of Thousand Creek Cañon possibly retarded it still farther.

During the process of excavation of Virgin Valley there appear to have been several resting stages of which some record is left in terraces. At least two levels of terracing seem to be indicated on the slopes of the valley. Both represent levels of relatively slow accumulation of alluvial fans, which have been followed by periods of cutting in which the ends of the older fans have been sharply truncated. The levels of these terraces are about twenty feet and forty feet above the present floor of the valley.

In the course of excavation of the valley, numerous landslides have evidently been an important feature in the movement of material from the walls of the bordering table-lands.   On both sides of Virgin Creek numerous large blocks of the mesa with the basalt capping almost intact are seen in various positions on the slope below the lava cap (pl. 11, fig. 1).   On the edge of the mesa, blocks half a mile or more in extent may be seen in the first stages of movement.   In the lower part of the valley near the union of Virgin Creek and Beet Creek a long series of lava-capped hills reaches for a
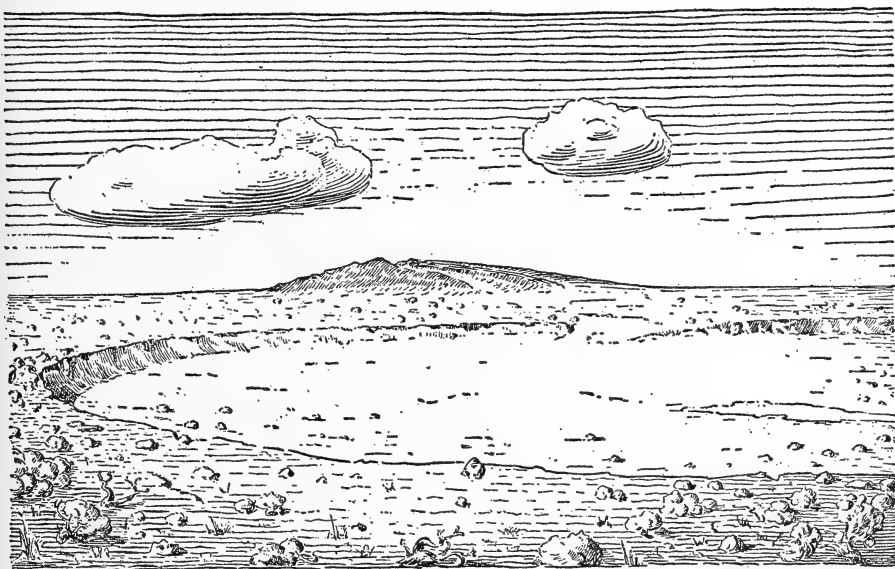
Fig. 4.   A portion of the mesa south of Virgin Valley.   Antelope Butte, a prominent dome of rhyolite in the background, rises above the level floor of basalt.   The circular lake in the foreground is surrounded by steep walls of basalt.

distance of at least two miles from the mesa down to the present stream-bed (see pl. 5).   The strata in these hills are frequently sharply inclined, usually with the dip toward the mesa (pl. 11, fig. 2).   The lava capping consists of material identical with that in the basalt cap of the mesa.

The separation of large blocks from the valley wall is evidently due in a considerable measure simply to the cutting of small streams, the basalt cap having protected the underlying mass until the wall was cut down to a very steep slope.   The breaking away of blocks

of large size is evidently assisted greatly by seepage developed through breaks in the lava cap. The presence of such channels of seepage on the mesas both north and south of Virgin Valley is evidently indicated by a series of peculiar lakes scattered over the table-lands. The lake basins, in some cases at least a mile in diameter, are situated on the level lava tables (fig. 4). They are usually approximately circular, with steep marginal walls formed by the basalt. Though the lava cap has disappeared over the area of the lake basins, there is no lateral outlet for wash. The only supposition on which we can account for the presence of these depressions seems to be that they have been formed by the sinking of the lake floor. This would most probably be caused by lines of seepage causing readjustment of the ash strata below, partly through the condensing effect of water on the beds of loose ash. Seepage of this character would also tend to separate large blocks from the main valley wall. Depressed areas, developed some distance away from the margin of the mesa, when reached by recession of the valley wall would presumably tend to move as large slides.

In the movement of the numerous blocks which have been detached as slides from the mesa walls it is not improbable that earthquake shocks have played a part of some importance. In the fault movement which caused the four hundred foot displacement along the east side of Thousand Creek Ridge in post-Mesa-Basalt time, earthquakes of considerable violence probably occurred.

Suggestions of a stage during which considerable volumes of sediment may have accumulated in the valley before it had attained as much as one-half of its present depth are offered by a bed of gravel and boulders which covers the top of a prominent ridge in the angle between the drainage of Virgin Creek and Beet Creek (pl. 8). At this point the top of the spur running out from the sharp eastern point of the mesa is covered with at least fifty feet of coarse gravel and boulders. Farther east Mr. Heindl measured a section of this gravel one hundred and twenty feet thick. At some points near the east end of the ridge these gravels are interbedded with strata which appear like a part of the Virgin Valley Formation. Along a large portion of the north side of this ridge the contact between the gravel and the underlying Virgin Valley Beds is very clearly exposed, and a strongly marked angular unconformity of at least ten degrees variation in dip is shown. At some points the underlying

strata are considerably contorted. The sharp minor folds might possibly be due to local slipping of soft strata below a contact with the gravels. The angular unconformity shown in a long exposure of the cliff can be interpreted only as the result of erosion preceding the deposition of the gravels.

The gravel deposits resting upon the eroded Virgin Valley Beds consist almost entirely of large, well-rounded rhyolite fragments ranging up to more than two feet in diameter. The rhyolite closely resembles some of the flows in the formation forming the rim of Virgin Valley. A very few well-rounded pebbles of basaltic lava were obtained. Mr. Heindl, who has examined this basalt, finds it very different from the Mesa Basalt. While basaltic pebbles are rare in the mass of these gravels, large blocks from the basalt capping of the mesa near by are found resting on the top of the gravel beds.

The unconformity of the rhyolitic gravels on the Virgin Valley Beds might be interpreted as meaning that it represents a stage of accumulation in a valley cut after the period of the Mesa Basalt flow. On the other hand it is noted that basaltic pebbles are quite rare in the rhyolitic gravels, while large masses of basalt from the edge of the mesa are found resting upon the top of these gravels. The edge of the basalt covering the mesa is near at hand, while the flows from which the rhyolite pebbles have been largely derived are much farther removed. It is moreover not probable that the few basaltic pebbles in the gravel are derived from the Mesa Basalt, and basaltic flows are presumably associated with the rhyolites below the Virgin Valley Beds. This evidence seems to show that the accumulation of the gravels occurred before the Mesa Basalt flow, otherwise there should be at least as large a percentage of fragments derived from the mesa cap as we find in other deposits known to have formed during the cutting of the present cañon.

The suggestion that the rhyolitic gravels accumulated at an early resting stage in the cutting of the present valley is probably further negatived by the presence of numerous large land-slides between these gravel beds and the present bed of Virgin Creek. If at an early stage in its history, the main stream had occupied the position in which the gravels are now situated, it must since then have cut to the south and east across the present valley. If this had occurred, the numerous remnants of slides from the mesa wall, which lie between the rhyolitic gravels and the present stream, would neces-

sarily have been removed. As a possible alternative the slides might be supposed to have travelled across the rhyolitic gravels and down into their present positions. This is certainly a violent assumption, as the slides are now separated from the mesa by one or two miles of relatively flat territory.

The weight of evidence seems to indicate that the rhyolitic gravels were deposited after a short stage of erosion which occurred during the general period of sedimentation characterized as the Virgin Valley epoch. This theory receives support from an observation by Mr. Furlong, who has noted the occurrence of beds of gravel and boulders in the face of some of the exposures of the Virgin Valley Beds one or two miles north of the main occurrence of the gravels. The exposures observed by Furlong were at about the same general level below the mesa as the main outcrop of the rhyolitic gravels. The gravel and boulders were interbedded with the ash strata, and as nearly as the writer can judge from Furlong's description they were of much the same nature as the main rhyolitic gravel outcrops.

Thousand Creek Beds

In the region immediately to the east of Thousand Creek Ridge there are extensive exposures of mammal-bearing beds bordering the basin known as Thousand Creek Flats. Large outcrops of these beds are present along the eastern base of Thousand Creek Ridge, and similar beds reach for many miles north from Thousand Creek. A long, narrow, lava-capped mesa known as Railroad Ridge extending nearly north and south for six or seven miles into the Thousand Creek basin is composed of similar beds (pl. 2 and text fig. 5). To the north of the Thousand Creek basin, near a prominent point known as Oregon End, the sedimentary series of Thousand Creek Flats apparently extends under a mesa which corresponds in general to the table-lands in the Virgin Valley region. The capping of this mesa is similar to the Mesa Basalt in Virgin Valley. On the northwestern border of the basin large outcrops of ashy beds, apparently representing the later Virgin Valley Beds, are visible beneath the basalt cap. To the east of Thousand Creek Flats the mammal beds come in contact with the upper portion of the Pueblo Range Series. The mammal beds here seem to extend in nearly horizontal position over to the contact with the rather steeply inclined upper beds of

the Pueblo Range Series, so that the relation of the two groups of beds is apparently one of unconformity.

The principal exposures near Thousand Creek consist of tufaceous beds, ashes, and sands, ranging from white to red and dark brown. Many of the strata presumably represent ancient soil accumulations much like that covering the floor of the valley at the present time. Distinctly sandy layers appear a short distance below the top of the section at the northern end of the basin, and also in the beds at the southern extremity near Thousand Creek Ridge. A layer of white to gray ash, one to two feet thick, is exposed low in the section near Thousand Creek Ridge, and one is also seen in the beds at the northern end of the basin. The two may represent the same horizon, but they have not been traced through the series of exposures. Beds of gravel of considerable extent are also present. In some instances the gravels may represent terrace deposits of more recent age than the principal exposures of mammal beds in the basin.

SECTION C-D

Fig. 5. Section along the C-D line on plate 2, showing section from Thousand Creek Ridge to Railroad Ridge.

Both the southern and northern exposures in Thousand Creek basin are truncated by a terrace or mesa having approximately the same level as the top of Railroad Ridge. An exception to this is seen in a prominent hill which rises above this table and above Railroad Ridge in the northern exposures.

Around the borders of Thousand Creek Flats there are several distinct terraces which are much below the level of the Railroad Ridge mesa, and are evidently of late Pleistocene age. They are shown in the broad flats situated just south of Railroad Ridge. This bench is about sixty feet above the present level of the stream bed and is apparently underlaid in a large part by undisturbed mammal beds.

The Thousand Creek Beds are in general approximately horizontal, or dip slightly toward the southwest; that is, toward Thousand Creek Ridge. In the exposures at the northern end of the section the strata are noticeably tilted, and the dip does not appear to be conformable with the plane of the terrace or mesa above.

The nature of the beds exposed in Thousand Creek basin is in a general way similar to that of the sedimentary formation in Virgin Valley, though it does not repeat the characters of any particular portion of the Virgin Valley section. Possibly more sandy strata have been seen in the Thousand Creek section than were actually noted in the beds in Virgin Valley. If the Thousand Creek exposures represent the same epoch of deposition as those of Virgin Valley, it is evident from the contained fauna that they must correspond to the upper portion of the Virgin Valley Beds rather than to the lower portion of that section.

So far as known, the mammal collections from the beds around Thousand Creek Flats all seem to represent one fauna, with the possible exception of a few remains obtained from deposits which occur on some of the lower terrace levels in the valley. The few specimens obtained from the terraces seem to represent a member of the horse group very near in its characters to the Quaternary genus *Equus*, whereas the other horse remains from the Thousand Creek exposures certainly represent an older group. As the remains from the terraces are fragmentary, it is possible that they do not actually represent forms very different from the other specimens, which are better preserved. It is also not at all certain that the deposits below the apparent terrace levels are distinct from the other Thousand Creek exposures.

With the exception of the possible Quaternary remains from Thousand Creek, the mammalian fauna which is found widely spread in the exposures of this region represents a stage of the late Tertiary, but apparently not the very latest portion of the Tertiary.

In comparing the fauna of Thousand Creek with that of the Virgin Valley Beds, there are found to be a few species common to the two; but by far the greater number of the species, and even of the genera, are different. In most respects in which it is possible to make a comparison, the Thousand Creek forms are more advanced or more specialized than those of Virgin Valley. Judging by the fact that a few species are common to the two faunas, there is reason for considering them as not widely separated in time. On the other hand, it is difficult to place them in the same epoch, and it is evident that the Thousand Creek fauna is the later one.

A summing up of the evidence presented by the Thousand Creek fauna with reference to the age in relation to that of the other

formations of this region shows the following points: (1) The Thousand Creek fauna is of late Tertiary age; (2) It is later than the fauna obtained from the lower and middle Virgin Valley Beds; (3) It was not widely separated in time from the known Virgin Valley fauna, as there are a few mammalian species common to the two.

Although resembling the Virgin Valley Beds in a general way, it is evident from their contained fauna that the wide extent of exposures in which collections of fossil mammals have been made in the Thousand Creek region cannot represent the lower or middle portion of the section in Virgin Valley, in which the typical Virgin Valley fauna has been found.   Unfortunately almost nothing is known of the fauna from the uppermost portion of the Virgin Valley section, possibly because the steep exposures immediately below the basaltic capping present a collecting area relatively much smaller than that representing the lower horizons.   It is therefore necessary to reckon with the possibility that the exposures at Thousand Creek represent the upper portion of the Virgin Valley section.

If the Thousand Creek exposures be held to represent the uppermost portion of the Virgin Valley section, the present position of the beds in the western part of the Thousand Creek region could be accounted for only on the assumption of very extensive faulting along Thousand Creek Ridge.   The fossiliferous beds immediately east of this ridge are now at least a thousand feet lower than the uppermost beds in Virgin Valley, while the drop of the mesa cap east of the fault-line along Thousand Creek Ridge to the north amounts only to a little more than four hundred feet, which is not sufficient to account for more than half of the difference in position, even when original slope of the land and possible recent tilting of the whole region to the east are considered.

The Railroad Ridge mesa, which contains some of the important deposits of the Thousand Creek region, is capped with a basaltic lava which is considered by Professor G. D. Louderback and Mr. E. L. Ickes, who have examined it, as representing the same type of rock as that in the Mesa Basalt.   The capping of Railroad Ridge is about four hundred feet lower than that portion of the main mesa to the north, which has been faulted down to the east of the Thousand Creek Ridge fault.   There is therefore some reason for considering that Railroad Ridge, and presumably the mammal beds exposed near it, belong to a block which has dropped very far below its original level.

Mr. Heindl, who has examined the section of Railroad Ridge (see fig. 5, p. 941), finds the uppermost beds composed of very coarse gravels consisting of pebbles of rhyolite, basalt and obsidian, and has suggested that this ridge represents an ancient lava-filled river bed. The course of the ridge runs out from the vicinity of the existing cañon of Thousand Creek, and would suggest a drainage passing near the line of the existing cañon (see pl. 2). If the river bed was present immediately before the outpouring of the Mesa Basalt and before the later movements along the Thousand Creek fault, this portion of the lava flow might be presumed to have resisted erosion longer than the adjoining portions owing to the original greater thickness of the lava over the channel of the old stream.

The idea that the Railroad Ridge lava represents the basalt filling of an old river bed also suggests that the Thousand Creek Beds might have accumulated in part from erosion of the western fault block previous to the outpouring of the Mesa Basalt. If extensive movement occurred along the Thousand Creek fault line before the outflow of the Mesa Basalt, accumulation may have taken place to the east of this line. During the time of such accumulation probably no deposits would be formed over the Virgin Valley region. Unless the whole region were reduced to the same level following such differential movement, one would expect to find the Mesa Basalt accumulating to much greater thickness east of the fault line, which is not clearly shown. A movement in pre-Mesa Basalt time, such as is suggested here, would presumably not result in more than a relative thickening of the beds to the east of the fault line, and possibly in a temporary interruption of sedimentation over the block west of the fault line.

Another possible explanation of the Railroad Ridge gravels, and of the Thousand Creek Beds in part or as a whole, is that they have been derived from the wash of Thousand Creek or other similar streams during the cutting of Virgin Valley. As a rough estimate, we may consider that at least ten cubic miles of rock have been carried out of Virgin Valley since the initiation of the cutting of the present valley. As nearly as one may judge, the distance to which this material could have been carried was short, and it could have been deposited over only a small area. It is therefore not improbable that some part of this material may have been deposited on the east side of Thousand Creek Ridge, particularly after the faulting movements occurred along the line of this ridge.

According to the hypothesis just suggested, it would be necessary to consider either that the Thousand Creek Beds have been lowered by faulting since their deposition, or that they were accumulated very late in the history of the cutting of Virgin Valley. The beds forming Railroad Ridge are now far below the top of the mesa in Virgin Valley, and we can hardly imagine them as derived from the first sediment washed out in the cutting of the uppermost strata of the Virgin Valley Beds a few miles away and deposited in their present position. Without considering that differential movement has changed the position of these beds in relation to the Virgin Valley Beds since their deposition, it would be necessary to suppose the Thousand Creek Beds formed from sediment obtained during the cutting of the lower or later portion of Virgin Valley.

The possibilities as to age of the Thousand Creek Beds with relation to the Virgin Valley Beds appear to be as follows: (1) They represent a portion of the Virgin Valley Beds faulted down into their present position. (2) They are younger than the Virgin Valley Beds, but older than the Mesa Basalt, and have been moved down by faulting. (3) They represent an accumulation formed of the *older* wash derived from the post-Mesa-Basalt erosion of the existing valleys of Virgin Creek and Beet Creek, or other similar drainage, and have since their accumulation been dropped by faulting. (4) They represent an accumulation of sediment laid down during the period of erosion of the lower or *younger* portions of these valleys. (5) They are not a stratigraphic unit, and may be partly of the age of the Virgin Valley Beds and partly later.

Without more detailed geologic information than it has been possible to obtain, it is not entirely clear as to which of these possibilities corresponds to the actual history.

The first possibility has much in its favor, *viz.*, that the Thousand Creek Beds represent a series of deposits which are comparable to the late Virgin Valley Beds and have been faulted down to their present position.

The second case suggests a situation which is a possibility, though the evidence does not seem to indicate definitely that this has been the mode of accumulation of these beds.

According to the third and fourth possibilities, *viz.*, that the Thousand Creek Beds represent an accumulation of wash carried out in the excavation of Virgin Valley and other valleys of approxi-

mately the same age, it must be presumed that the beginning excavation of Virgin Valley occurred a considerable time before the close of the Tertiary, as the Thousand Creek fauna antedates the end of the Tertiary. It would then be necessary to consider that the comparatively thin sheet of Mesa Basalt has been able to protect the Virgin Valley Beds beneath it from erosion through the whole of the Pleistocene and a part of Pliocene time, unless some later formation has in turn protected the Mesa Basalt. It seems improbable that the Mesa Basalt has been covered by considerable deposits of any kind, as the large level stretches now exposed appear to be entirely bare.

There is strong evidence against the suggestion that the Thousand Creek Beds represent an accumulation of the latest wash from Thousand Creek and other similar drainage, as this would increase the length of the period back to the initiation of the first cutting through the Mesa Basalt. The strongest argument in favor of relatively late age of the Thousand Creek Beds is obtained by Heindl's study of the Railroad Ridge lava, and by his discovery of a basalt pebble in the gravel immediately under the lava. The basalt pebble from the gravels below the lava is considerably decomposed, but seems to be rather nearer the type of the Mesa Basalt than it is to that of the older Pueblo Range lavas. Heindl has also called attention to the fact that the Railroad Ridge lava is not broken up as it might be if it were a block which had been dropped a considerable distance. In the absence of well preserved material, the basalt pebble from below the lava is hardly sufficient evidence to prove that the Railroad Ridge lava is a flow of later age than the Mesa Basalt. The lack of disturbance of the Railroad Ridge lava does not necessarily indicate that this block has not been moved, though minor disturbance might naturally be expected.

Judging from the evidence of the fauna, it seems probable that the Thousand Creek exposures represent in the main a single period of deposition. Upon the lower terraces bordering the valley there may be Pleistocene deposits with a fauna containing *Equus*. Such deposits, if they occur, are apparently not thick, and their presence would hardly confuse the problem as to the age of the great extent of exposures with a late Tertiary fauna.

It is very desirable that more evidence be obtained relative to the purely geologic history of the beds at Thousand Creek. A deter-

mination of the exact geologic position of these beds may depend finally upon a study of the fauna, but from the standpoint of the palaeontologist it is most desirable to have the evidence of sequence of faunas based upon stratigraphic succession.

High Rock Cañon Exposures

About thirty miles southwest of Virgin Valley a number of exposures were found to contain a fauna similar to that of the Virgin Valley Beds. The localities at which collections were made are near High Rock Cañon and Little High Rock Cañon (see pl. 1).

The beds in which the mammalian remains were obtained consist of ashy or tufaceous materials resembling some of the exposures in Virgin Valley. The region bordering the valley in which the mammal beds appear is largely lava-covered, and according to Heindl and Furlong the fossil beds appear to dip under the lavas at some localities. Whether the apparent position of the lava over the mammal beds is an original stratigraphic relation is uncertain, as there is considerable faulting in this region. The nature of the lavas here is not certainly known, but a rhyolite seems to form the greater part of the outcrops. A further study of this region is desirable.

During the period in which the Virgin Valley Beds were being deposited there was probably more or less accumulation of similar materials over a wide area in this region. The deposits laid down at this time may have formed extensive continuous sheets in some localities. In this particular place accumulation may have taken place in small separated basins formed through faulting.

Physical Conditions Obtaining during Deposition of Virgin Valley and Thousand Creek Beds

The sedimentary deposits, and the fossil remains which have been found in them at Virgin Valley, show that there was some variation in the physical conditions obtaining in this region in late Tertiary time. During the deposition of a portion of the lower beds in Virgin Valley, swampy or moist ground covered a considerable area, and thin lignitic deposits were formed. Particularly during the deposition of the middle portion of the Virgin Valley Beds, there was a partial forestation of the region, as is evidenced by the abundant petrified remains of large trees preserved in these strata. The mammalian fauna of the Virgin Valley Beds is in general that of a fairly open country.

In the Thousand Creek Beds, representing a later period than the lower portion of the Virgin Valley section, no evidence of lignitic deposits like those of Virgin Valley has been noted. During this epoch the mammalian fauna included many forms which are commonly found on open plains, as antelopes, camels, horses, and rhinoceroses. It is probable that at this time the conditions here were not greatly different from those obtaining in the less arid areas of the northern part of the Great Basin at the present day.

Summary of Principal Events in the Geologic History of the Virgin Valley Region

Following is the succession of principal events in the depositional and erosional history of the Virgin Valley region. The Thousand Creek Beds have been omitted from this scheme, as their position in the column is largely determined by palaeontologic data which are naturally presented in the second part of this paper. As the geologic studies presented here have been undertaken for the purpose of assisting in an understanding of the history of mammalian life, in the following table the evidence used is that obtained without the aid of palaeontology. In the general discussion of age and relationships of the faunas, which will appear in Part II of this paper, the evidence of age has been assembled from all sources. .

Terrace formations.	Terracing, and accumulation of gravels in later history of Virgin Valley.
Cañon cutting	Cutting of Virgin Valley to depth of nearly 1500 ft.
Mesa Basalt	Outpouring of wide-spread but thin sheet of basalt.
Virgin Valley Beds	Accumulation of at least 1500 ft. of ash, tuff, and carbonaceous shale.
Epoch of erosion	Erosion probably accompanied by faulting.
Pueblo Range Series	Accumulation of much more than 1000 ft. of basalt, tuff, and rhyolite. Rhyolite following basalt.

With reference to the age or correlation of the formations included in this list, the following opinions have been expressed:

Virgin Valley Beds
{ Merriam.[14] 1907. Miocene; upper beds not older than Mascall Beds of John Day region; lower beds Miocene, but may represent a different phase.
Gidley.[15] 1908. Middle or lower Miocene; not newer, and may be older than Mascall Beds. }

[14] Op. cit., p. 382. 1907.
[15] Op. cit., p. 242. 1908.

Pueblo Range Series
{
Blake.[16] 1875. Early Miocene.

Merriam.[17] 1907. Cañon Rhyolite of Virgin Valley superficially resembles a part of the Clarno Eocene series of the John Day region.

Waring.[18] 1909. The lava series forming a large part of Steens Mountain is correlated by Waring with the Columbia River basalt (Miocene). The Steens Mountain lavas are presumably the same as the Pueblo Range Series.
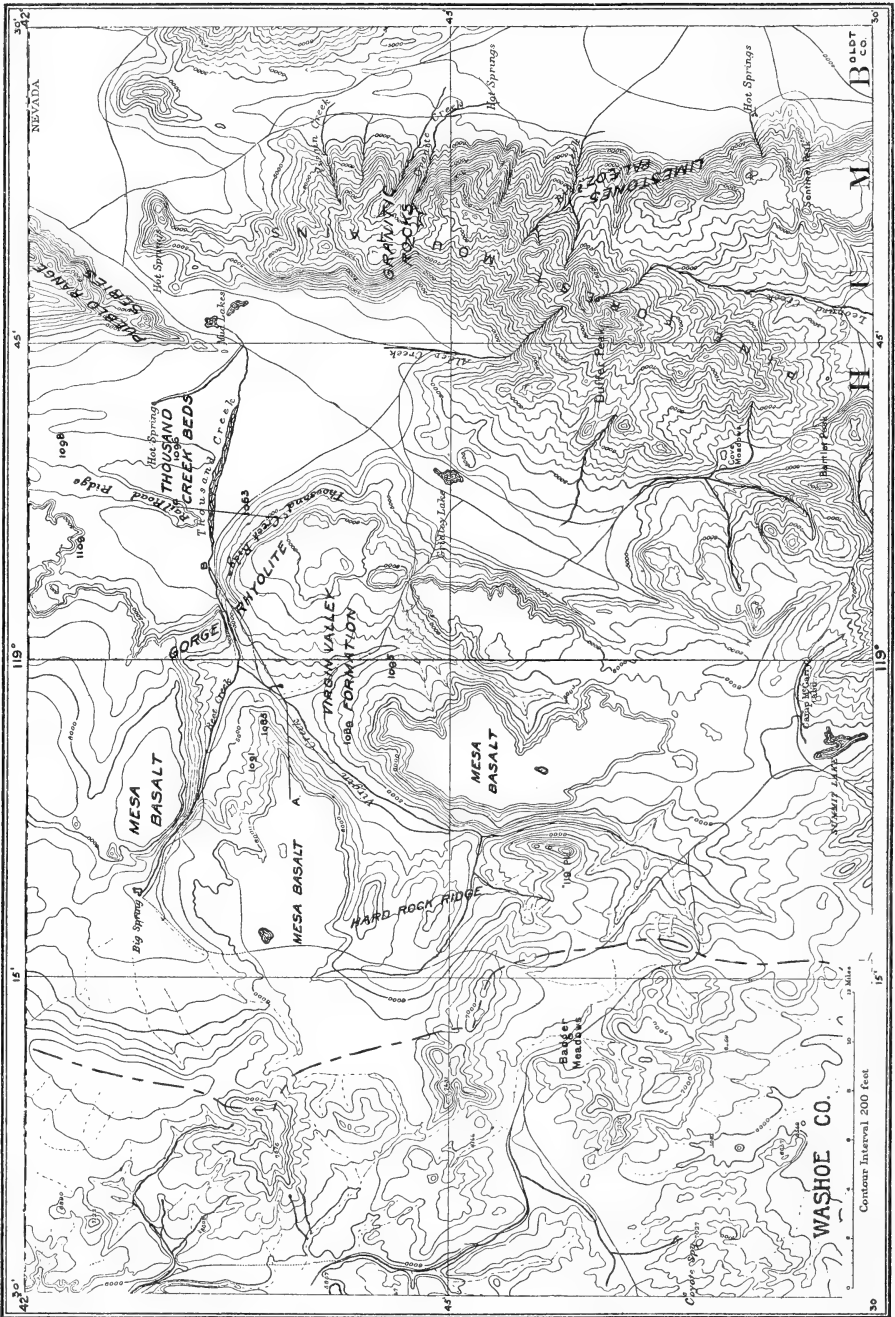}

[16] Op. cit., p. 212. 1875.
[17] Op. cit., p. 381. 1907.
[18] Op. cit., p. 21. 1909.
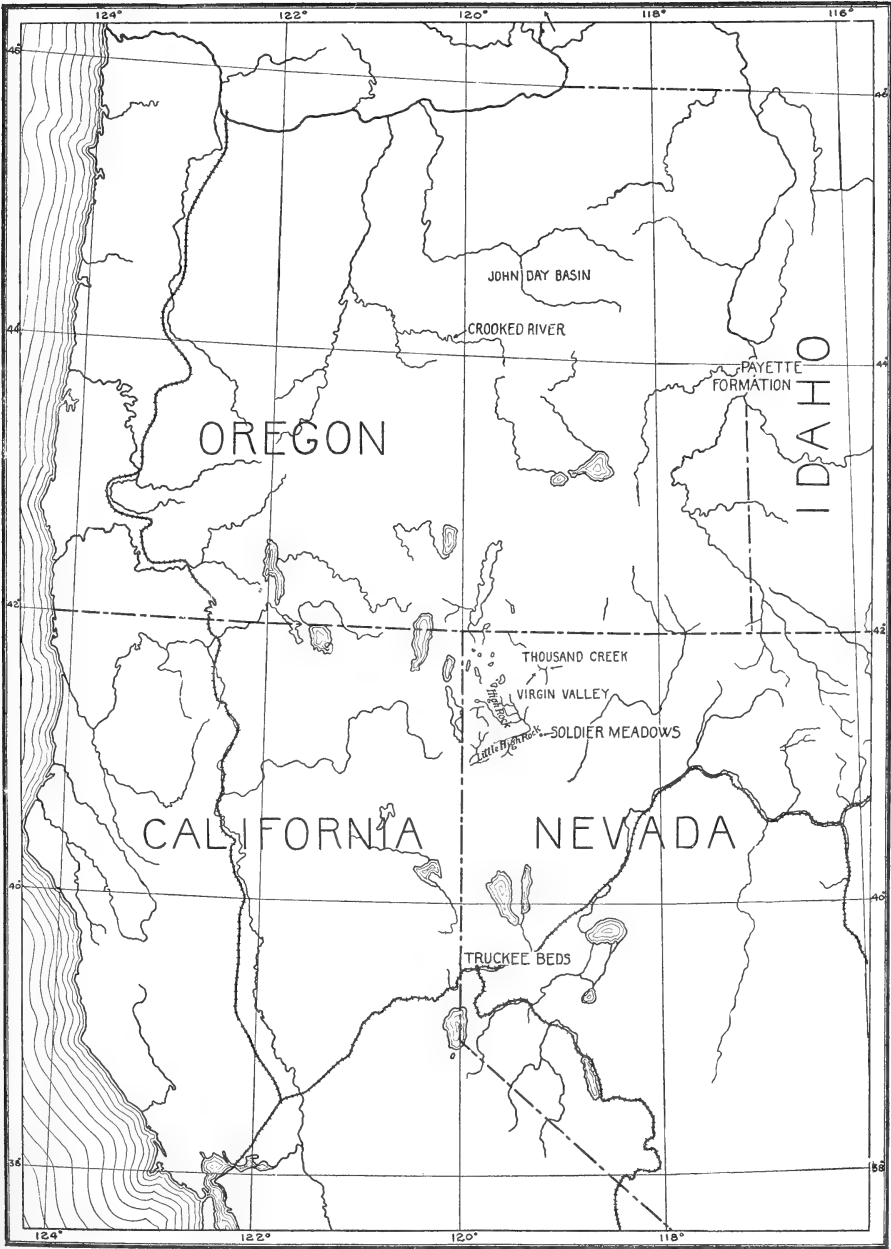
Outline map showing situation of the Tertiary mammal-bearing beds of northwestern Nevada

Contour map of region about Virgin Valley. Adapted from U. S. Geological Survey topographic maps.
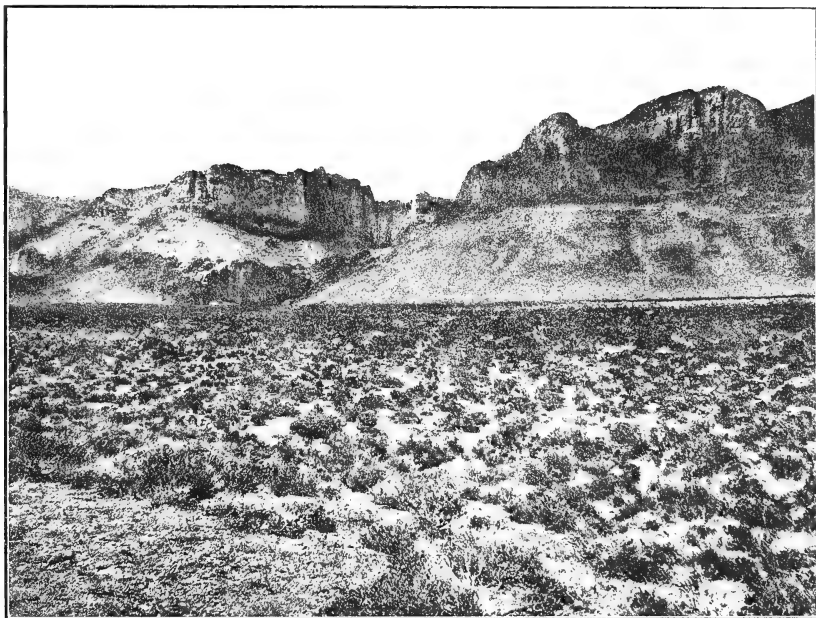
FIG. 1. Thousand Creek Ridge, and eastern entrance to Thousand Creek Cañon, showing fault scarp and prominent exposures of Cañon Rhyolite.
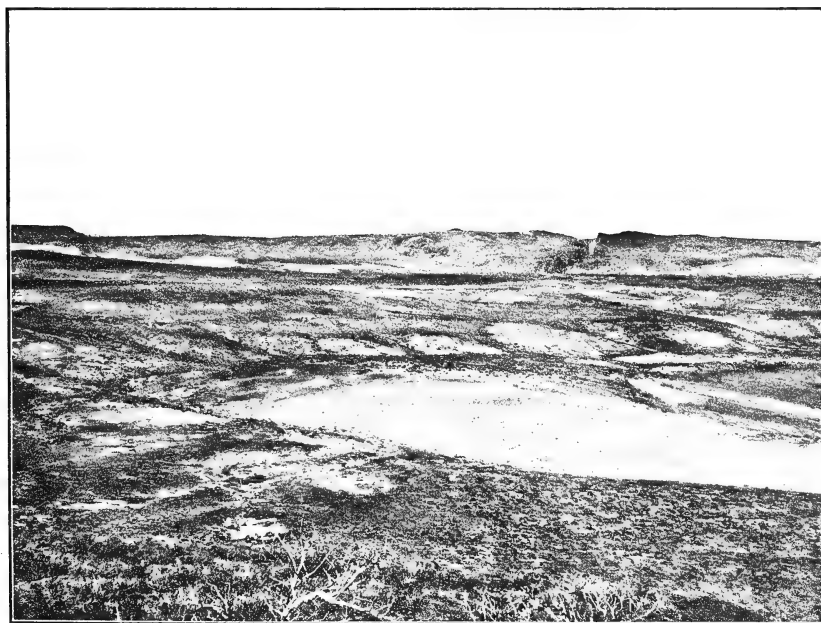
FIG. 2. Thousand Creek Cañon seen from the western or Virgin Valley side. Thousand Creek Ridge in background composed of Cañon Rhyolite. Virgin Valley Beds in foreground.
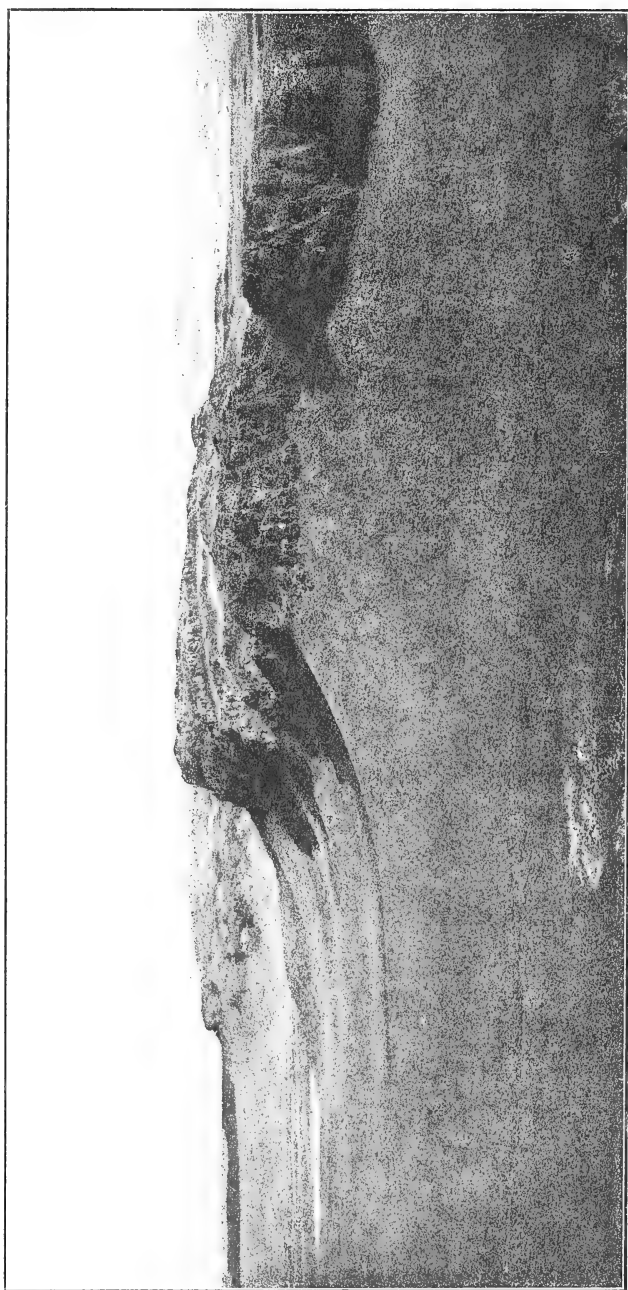
Thousand Creek Ridge seen from the north. Eastern entrance to Thousand Creek Cañon opposite the arrow to left of picture. Virgin Valley to right of ridge, Thousand Creek Flats to left.

View of Virgin Valley looking west across the valley of Virgin Creek from the foot of Thousand Creek Ridge. Basal Virgin Valley Beds in foreground. Mesa in background composed of Virgin Valley Beds capped by Mesa Basalt.
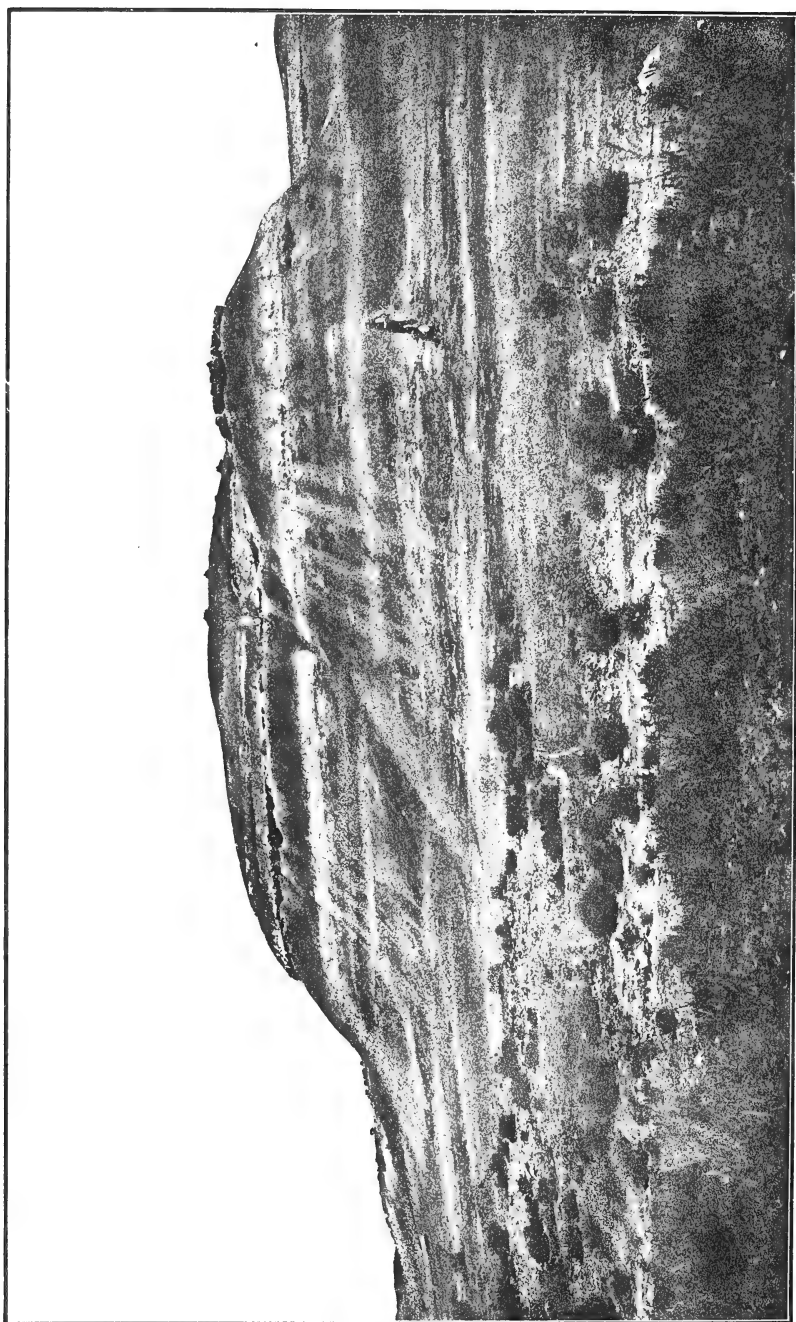
Lower Virgin Valley Beds with mammal-bearing strata covered by carbonaceous shales.　East side of Virgin Valley.

Carbonaceous shales with thin seams of lignite. Lower phase of Virgin Valley Beds, south side of valley of Beet Creek.
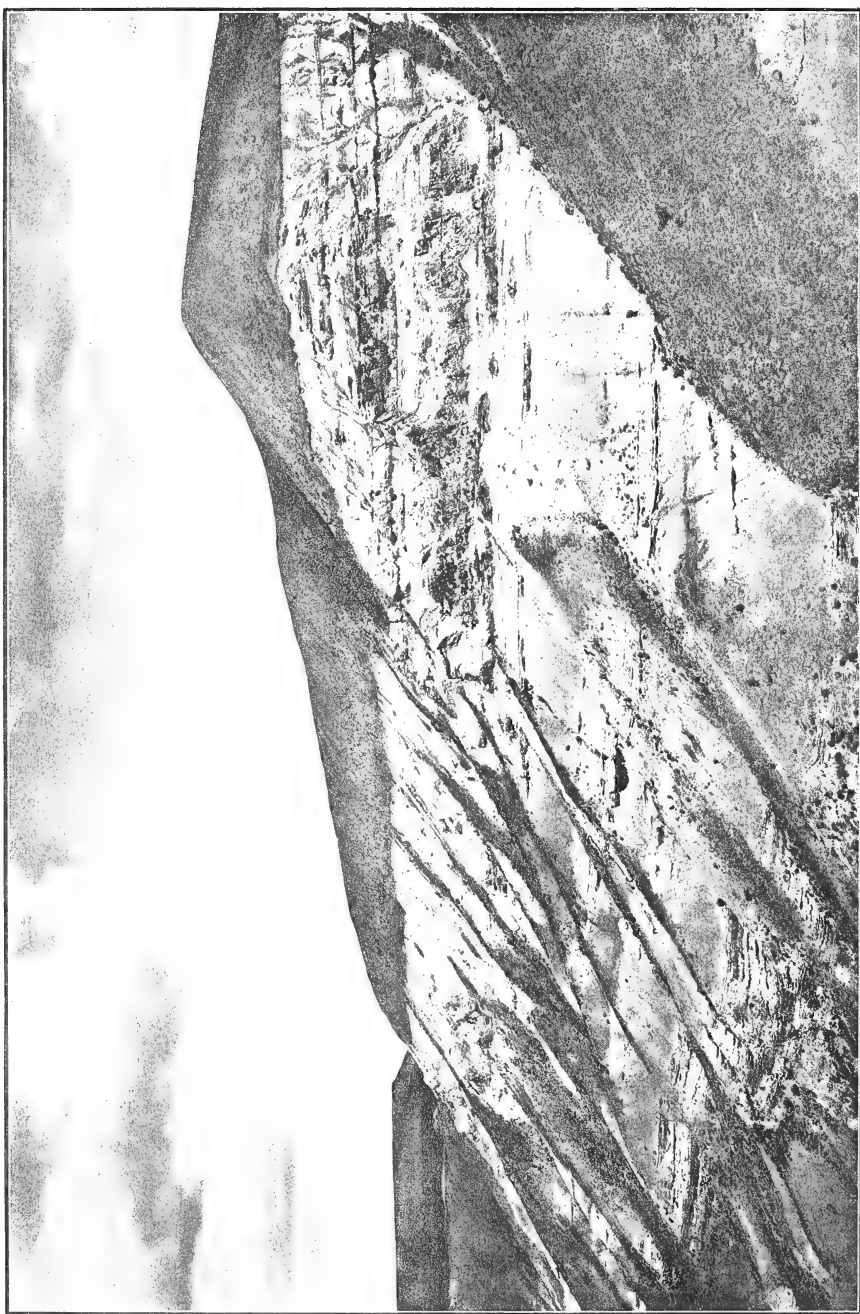
Middle division of Virgin Valley Beds covered unconformably by rhyolitic gravels. South side of valley of Beet Creek.
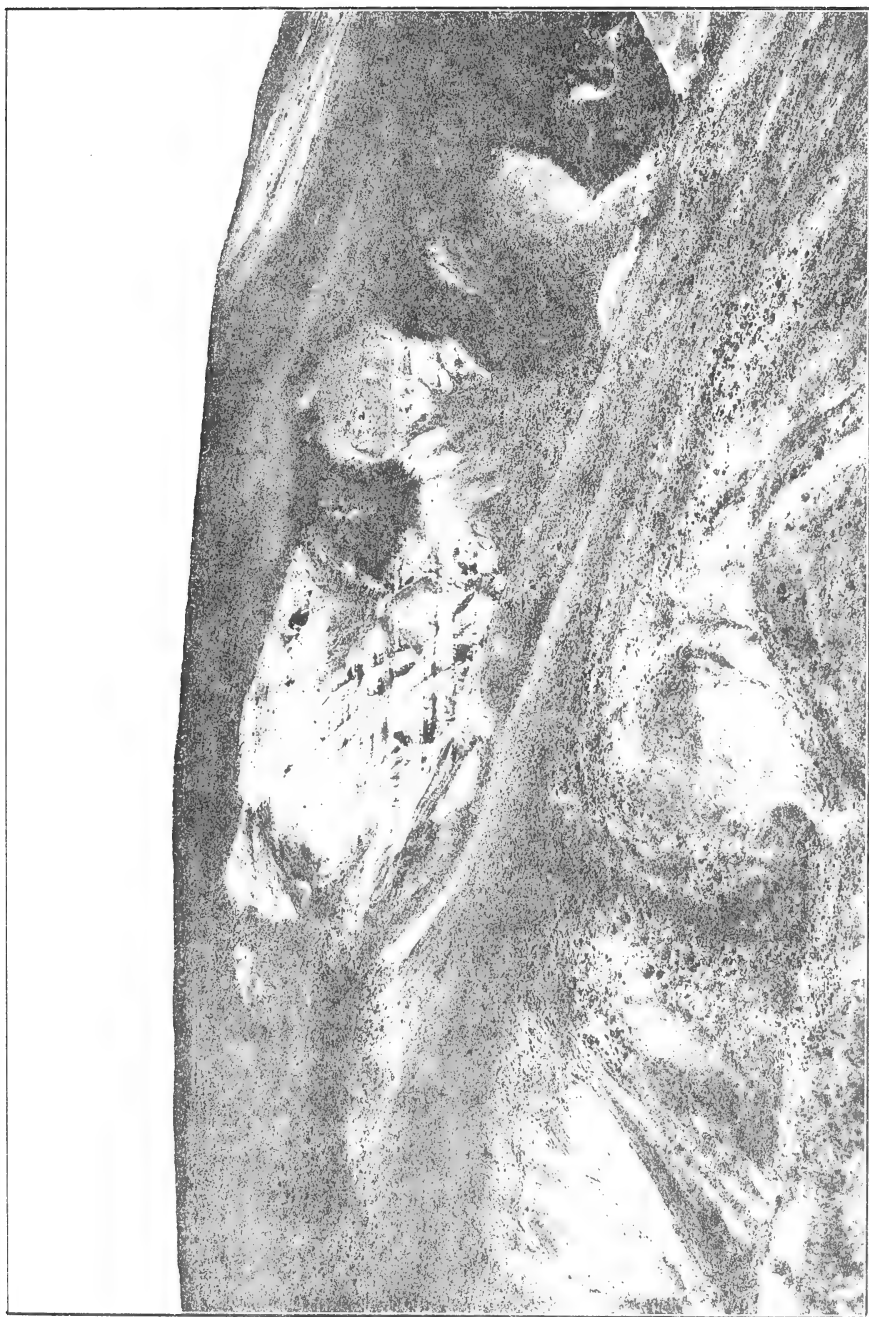
Upper Virgin Valley Beds covered by Mesa Basalt. Northwest side of valley of Virgin Creek, exposure near A of A–B line shown on plate 2.

View of mesa north of valley of Beet Creek. Table land capped by Mesa Basalt resting upon Virgin Valley Beds. Cañon Rhyolite underlying Virgin Valley Beds in middle distance to left of picture. See also text-figure 3.
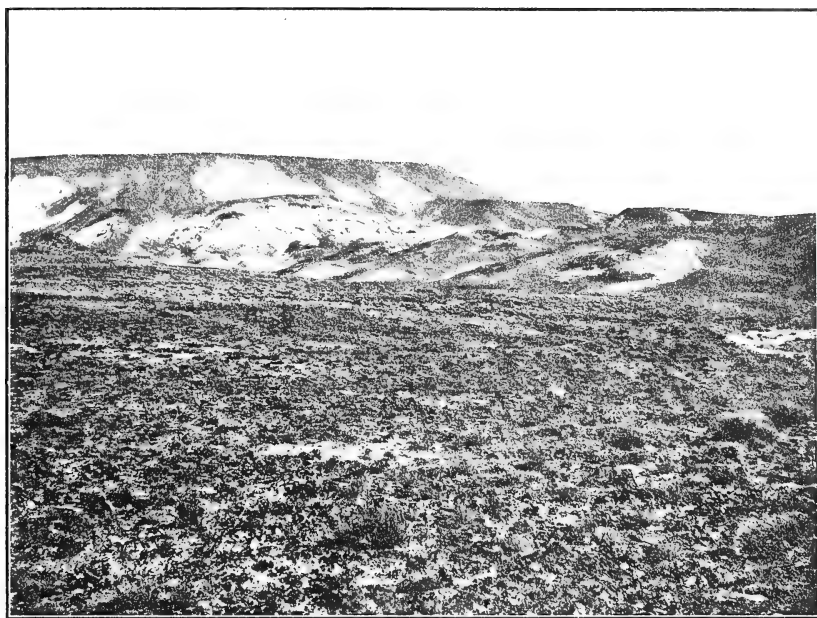
FIG. 1.   East end of mesa between valleys of Virgin Creek and Beet Creek, showing large blocks recently moved down from top of mesa.
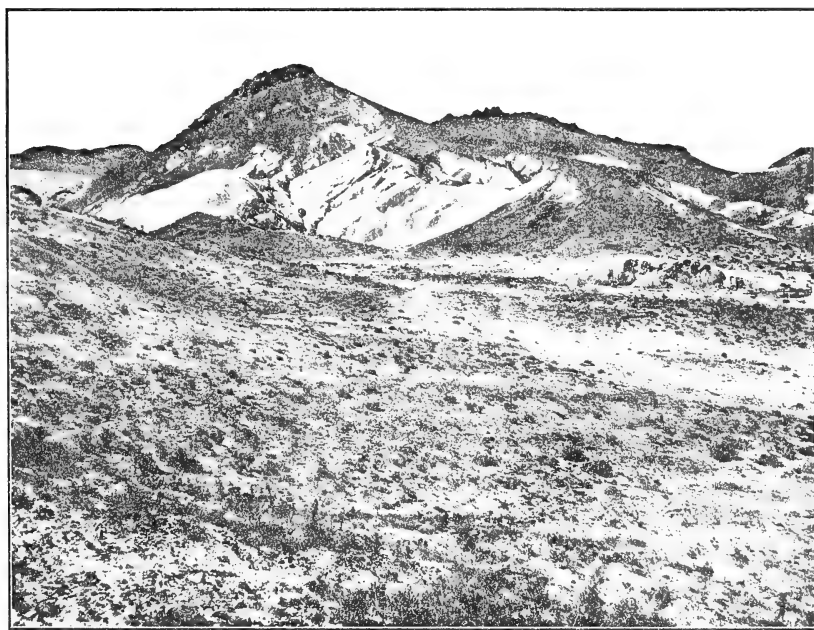
FIG. 2.   Much disturbed masses of Virgin Valley Beds with lava capping.   Presumably representing old slides.   Northwest side of valley of Virgin Creek.
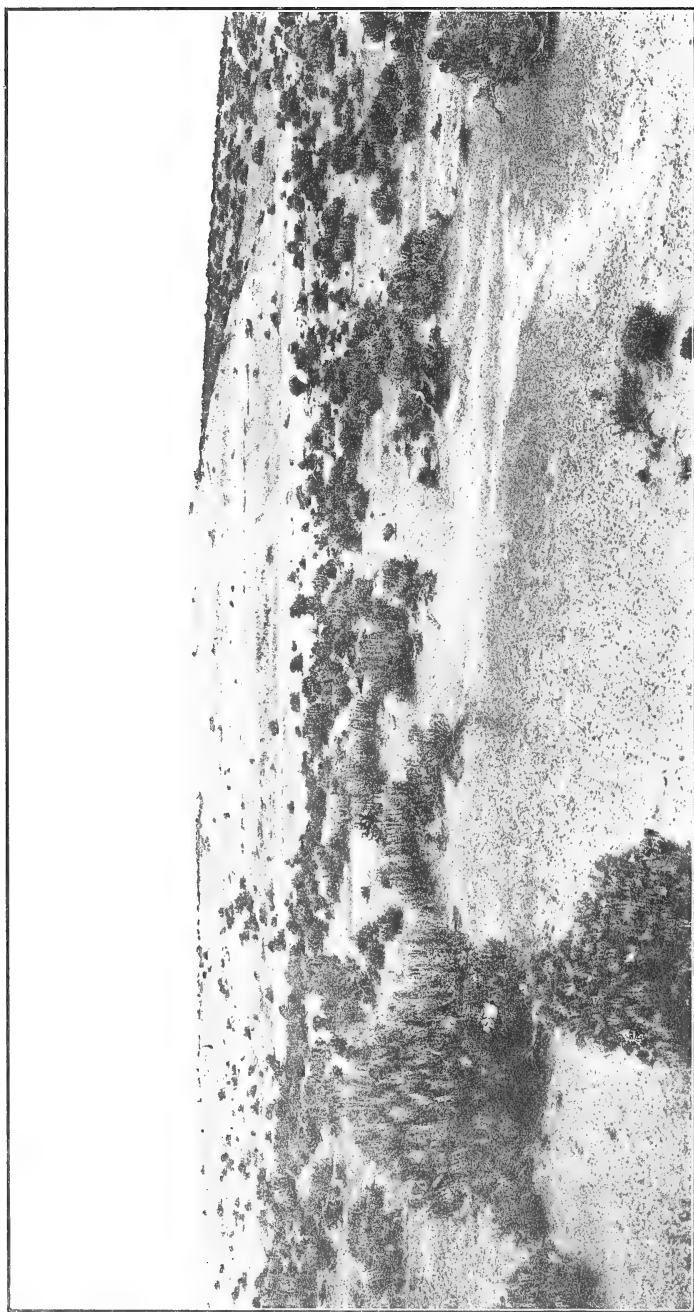
Exposure of Thousand Creek Beds.   Northern portion of Thousand Creek basin.

TERTIARY MAMMAL BEDS OF VIRGIN VALLEY AND THOUSAND CREEK IN NORTH-WESTERN NEVADA

PART II. VERTEBRATE FAUNAS

CONTENTS

Introduction

IN A recent publication,[1] of which the present paper is considered as Part II, the writer has discussed the general features of the formations in the geologic section containing mammal-bearing beds in the region of Virgin Valley and Thousand Creek in northwestern Nevada. The present paper presents such evidence as is available regarding the vertebrate faunas obtained from the Virgin Valley and Thousand Creek formations. An attempt is also made to determine the approximate age of the faunas by use of both palaeontologic and geologic criteria of correlation.

[1] Merriam, J. C., Tertiary Mammal Beds of Virgin Valley and Thousand Creek in Northwestern Nevada, part I, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 21–53, 1910.

A short list of the most characteristic forms in the fauna of Virgin Valley was published by Merriam[2] in 1907. In 1906 Gidley[3] discussed a number of the most characteristic ungulate species from the collections of the University of California. In 1910 Furlong[4] described a peculiar aplodont rodent from Virgin Valley, this form being the earliest known representative of the true aplodonts. In a recent paper Miss Louise Kellogg[5] has presented a description of the entire representation of the rodent group in the formations of Virgin Valley and Thousand Creek. Excepting the papers just mentioned, so far as the writer is aware, there are no published references to the vertebrate fauna of this region.

Although the collections from Virgin Valley and Thousand Creek furnish a most interesting representation of the mammalian fauna which inhabited these regions in late Tertiary time, the number of specimens obtained is relatively small compared with the collections which are commonly brought together in most of the series of mammal beds which have been investigated in this country. In Virgin Valley the number of localities where even fragments of bone are common is small. In the Thousand Creek Basin loose bones are quite abundant in many places.

In all of the exposures visited in this region the material consists almost entirely of scattered remains. Neither complete skeletons nor skulls could be obtained, though most careful search was made for them. Even when specimens were obtained in place in the rock they were found to consist entirely of isolated parts. There seems to be no question but that the bones were generally widely scattered, and usually in an advanced stage of disintegration before they were finally buried, which may be interpreted as a suggestion that the deposits represent in a large part dry land accumulations rather than those formed in lakes or swamps.

In the first publication of results of the work in the mammal-bearing beds of northwestern Nevada, the faunas of Virgin Valley and Thousand Creek were referred to collectively under the name of Virgin Valley fauna. More recent study has shown that the faunas of the formations at Virgin Valley and Thousand Creek are very

[2] Merriam, J. C., Science, n. s., vol. 26, pp. 380–382, Sept. 20, 1907.

[3] Gidley, J. W., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 235–242, 1908.

[4] Furlong, E. L., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 397–403, 1910.

[5] Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 421–437, 1910.

different, and it is desirable to consider them separately before entering upon a discussion of their relative age.

After completion of the following paper it was the writer's privilege to compare the fauna here described with the most nearly related forms represented in other museums. For the free use of specimens desired for comparison, and for courtesies extended in the course of this examination, the writer is particularly indebted to Mr. J. W. Gidley and Mr. C. W. Gilmore of the National Museum; to Professor Henry F. Osborn, Dr. W. D. Matthew, and Mr. Walter Granger, of the American Museum of Natural History; and to Dr. W. J. Holland of the Carnegie Museum.

All of the drawings used in illustration of this paper were prepared by Mrs. Louise Nash.

Fauna of the Virgin Valley Beds

Occurrence and Composition.—The section exposed in Virgin Valley has been more or less arbitrarily subdivided as follows:

Upper Zone.	White to buff beds. Ashes and diatomaceous beds.	} Upper Virgin Valley?
		Unconformity?[6]
Middle Zone.	Gray to yellow and brown shales and clays. Carbonaceous shales, lignites, diatomaceous beds.	} Lower Virgin Valley?
Lower Zone.	White to green, purple, and red clays and ashes.	

The zones as indicated above are not sharply defined, but where the attempt has been made to trace them they seem to be fairly persistent. Careful mapping of these horizons throughout the valley is desirable.

No mammalian remains have been found in Virgin Valley in characteristic beds of the lower zone, and only imperfect fragments were found in that portion of the section above the horizon at which an unconformity appears between the rhyolitic gravels and the underlying fine-grained beds.

Locality 1065, on the south side of the valley of Virgin Creek, the original locality at which mammalian fossils were found by McGhee, is immediately below the carbonaceous shales of the middle

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[6] Merriam, J. C., *op. cit.*, part I, pp. 36, 43, and pl. 8.

division; while locality 1091 on the west side of Beet Creek is a considerable distance above the carbonaceous shales.   Most of the other localities at which collections have been made in Virgin Valley would probably fall within the limits of vertical range marked by these two localities.   Mapping of the faunal and lithologic zones of the Virgin Valley Beds will probably show that the principal fossil horizons fall within a zone only a few hundred feet in thickness situated near the middle of the section.   Other fossiliferous beds are naturally to be expected both above and below this horizon.

The complete list of mammalian species obtained from all of the localities in the Virgin Valley Beds is as follows:

FAUNA OF VIRGIN VALLEY BEDS

Reptilia.
Clemmys, sp.

Carnivora.
Tephrocyon kelloggi, n. sp.
Tephrocyon(?), compare *rurestris* (Condon).
Tephrocyon(?), sp. *a*.
Aelurodon(?), sp.
Probassariscus antiquus matthewi, n. gen. & n. var
Felis, sp. ?

Rodentia.
Aplodontia alexandrae Furlong.
Mylagaulus monodon Cope.
Mylagaulus pristinus Douglass
Palaeolagus nevadensis Kellogg.
Lepus vetus Kellogg.

Ungulata.
Hypohippus, near *osborni* Gidley.
Parahippus, compare *avus* (Marsh).
Merychippus isonesus (Cope).
Aphelops(?) sp.
Moropus(?), sp.
Mastodon (*Tetrabelodon ?*, sp.).
Merychyus(?), sp.
Camel, near *Procamelus*.
Thinohyus(?), sp.
Blastomeryx mollis, n. sp.
Dromomeryx(?), sp. *a*, near *borealis* (Cope).
Dromomeryx, sp. *b*.
Merycodus, near *furcatus* (Leidy).
Merycodus nevadensis, n. sp.

The largest collection brought together at any one locality is that from the exposure discovered by McGhee, which probably represents the lowest horizon from which any considerable amount of material was collected.   The following forms were obtained at this locality:

LOWEST MAMMAL BEDS IN VIRGIN VALLEY, LOCALITY 1065

> *Tephrocyon kelloggi*, n. sp.
> *Mylagaulus monodon* Cope.
> *Palaeolagus nevadensis* Kellogg.
> *Lepus vetus* Kellogg.
> *Hypohippus*, near *osborni* Gidley.
> *Merychippus isonesus* (Cope).
> *Aphelops*(?), sp.
> *Moropus* (?), *sp.*
> *Blastomeryx mollis*, n. sp.
> *Dromomeryx*, sp. *a*, near *borealis* (Cope).
> *Merycodus*, near *furcatus* (Leidy).
> Mastodon (*Tetrabelodon* ?, sp.).
> Camel, near *Procamelus*.

Nearly all of the species from this locality are found also at other places and presumably at other horizons.   The only form not known elsewhere is *Palaeolagus*, represented by a single specimen.   The relative abundance of material at this place would make probable the discovery here of some of the rarer forms.   At other localities considered as higher in the section than no. 1065 the species are largely the same as at this horizon.   With these are a few rare forms, as *Merychyus* and *Thinohyus* (?), known by only one or two specimens, and representing groups typical of horizons much older than the lowest Virgin Valley beds are presumed to be, so that there is reason to believe that they were present during the deposition of the lowest mammal-bearing beds, but are sufficiently rare to have escaped observation in collecting thus far.   The only other important forms not known in the lowest horizon are *Aplodontia* and *Probassariscus*, each known by a single specimen.   The specimen of *Aplodontia* is doubtfully higher in the section than the beds at locality 1065.   *Probassariscus* was presumably a little higher.

From the above statement it appears that the fauna of the various localities in Virgin Valley is practically a unit, and may be considered collectively in any attempt at correlation.

Faunal Relationships.—The closest relationship of the Virgin Valley fauna seems to be with that of the Mascall Beds of Oregon

and of the Pawnee Creek Beds of Colorado. The Snake Creek Beds of Nebraska contain a larger percentage of the Virgin Valley species than either the Mascall or Pawnee Creek, but there seems, nevertheless, good reason for considering the relationship with the other faunas as closer.

The ungulate fauna of Virgin Valley fauna resembles that of the Mascall in the presence of *Hypohippus, Parahippus, Merychippus,* and *Dromomeryx;* and in the persistence of at least one oreodont (*Merychyus?*). The brachyodont horse *Hypohippus* has not been known from the typical locality of the Mascall, but has recently been noted by the writer in Mascall collections from the Crooked River region, south of the Blue Mountains in Oregon. At the type locality of the Mascall one other horse with short-crowned cheek-teeth (*Archaeohippus*) is represented. *Merychippus* is the most common horse in both the Virgin Valley and the Mascall, and *Pliohippus* is apparently absent from both faunas. The *Pliohippus* specimens reported from the Mascall are doubtful. *Tephrocyon,* the most characteristic carnivore of Virgin Valley, and *Mylagaulus,* the most characteristic rodent, are both included in the Mascall fauna.

With Pawnee Creek the Virgin Valley ungulate fauna has a large percentage of forms in common. In both faunas *Hypohippus, Parahippus,* and *Merychippus* are present without accompanying *Pliohippus.* The genera *Moropus, Merychyus, Blastomeryx* and *Merycodus* appear in both, while the rhinoceroses, mastodons and camels are suspiciously similar. *Mylagaulus* appears in both faunas, and some of the Pawnee Creek canids are doubtfully referred to *Tephrocyon.*

The fauna of the Snake Creek Beds of western Nebraska shows a remarkable similarity to that of Virgin Valley, a larger percentage of Virgin Valley species being found in the Snake Creek fauna than in any other assemblage of forms known to the writer. Particularly noticeable is the practical identity of several of the carnivore forms as *Tephrocyon, Felis,* and *Probassariscus.* The Virgin Valley *Probassariscus* differs from that of Snake Creek so slightly that the distinction may not be considered as of more than subspecific value. The deer-like forms *Dromomeryx, Blastomeryx,* and *Merycodus* appear in both faunas. Among the horses *Hypohippus, Parahippus,* and *Merychippus* are common to the two, but the abundance of

more advanced forms of the *Neohipparion* and *Protohippus* types indicate that the Snake Creek fauna must represent a stage considerably later than that of Virgin Valley. The difference between the two faunas presumably corresponds to a time interval about as long as that represented by the Upper Miocene, but is probably not longer than that division.

Determined according to the range of mammalian genera in North America, the Virgin Valley fauna must be considered as Middle Miocene. The generic types represented are those commonly found in the middle and upper divisions of the Miocene. The Lower Miocene is excluded by the advanced stage of development of the horses represented in *Hypohippus* and *Merychippus*, the extreme rarity of oreodonts, and the presence of advanced deer-like forms such as *Dromomeryx* and *Merycodus*. The presence of *Moropus* with a Thinohyus-like form and the absence of *Pliohippus* indicate a stage earlier than Upper Miocene. About equal numbers of upper and lower Miocene genera are present, but the Middle Miocene character of the fauna is indicated by the abundance of *Hypohippus* and *Merychippus* with the entire exclusion of any forms of the *Pliohippus* or *Protohippus* type.

Relation of Virgin Valley Fauna to its Environment.—The greater part of the mammalian material from Virgin Valley was obtained in the zone which includes the carbonaceous shales and lignite deposits. In this zone diatomaceous deposits are well developed, and fragmentary fish remains are occasionally found. Fossil wood of large conifer-like trees is abundant at many localities in this portion of the section. The nature of the deposit in general indicates that moist ground, swamps, and possibly even considerable bodies of water existed in this region during the period in which the typical Virgin Valley fauna flourished. Concerning the nature of the vegetation we know as yet comparatively little, as most of the remains obtained were imperfectly preserved. The plant specimens from the carbonaceous shales include rushes, willows, and a number of other forms not determined.

The nature of the deposits and of the contained remains in the principal mammal-bearing zone of the Virgin Valley Beds does not necessarily indicate that conditions were then entirely different from those obtaining in this region at the present time. Large marshy areas and lakes of considerable size existing today in the northern Basin region are the habitat of abundant plant and animal

life, while the most arid conditions may obtain only a few hundred yards from the water. Considering, however, the general persistence of moist conditions, and the nature of the vegetation indicated in this section, the weight of evidence indicates that the climate was more humid and somewhat warmer than at present. The vegetation suggests also that the altitude was probably less than 5000 feet, which is now approximately the level of the mammal zone in Virgin Valley.

As nearly as can be judged from our present knowledge, the Virgin Valley Beds were laid down over a region in which faulting had already produced a certain degree of relief. As the deposition progressed, the irregularities of topography were gradually smoothed over by filling in of the depressions, until plains or shallow lakes of wide extent had been developed.

The nature of the mammalian fauna occupying the Virgin Valley region in Middle Miocene time accords well with what one might expect in such an environment. *Probassariscus* among the carnivores, *Aplodontia* of the rodents, and the brachyodont *Hypohippus* of the ungulates suggest a region containing wooded areas. *Merychippus* and *Merycodus*, with long-crowned grazing teeth, suggest the open plains. As nearly as we can determine, both kinds of environment were available, and in localities so near together that remains representing the two types of faunas might readily be mingled in accumulations forming over the lowest areas of the region.

Fauna of High Rock Cañon and Little High Rock Cañon

The exposures at High Rock Cañon and Little High Rock Cañon resemble those of Virgin Valley in many respects. The collections made at these localities comprise the following forms:

HIGH ROCK CAÑON	LITTLE HIGH ROCK CAÑON
Tephrocyon(?), compare *rurestris* (Condon).	*Moropus*(?), *sp.*
Tephrocyon(?), sp. *a*.	
Aelurodon(?), sp.	
Merychippus isonesus (Cope).	
Merychippus, near *seversus* (Cope).	
Aphelops(?), sp.	
Moropus(?), sp.	
Mastodon (*Tetrabelodon* ?, sp.).	
Blastomeryx mollis, n. sp.	
Merycodus nevadensis, n. sp.	

The affinities of this fauna with that known from Virgin Valley are close enough to indicate that the beds near High Rock Cañon probably represent the same epoch as the mammal beds of Virgin Valley.

Fauna of the Thousand Creek Beds

Occurrence and Composition.—The beds at Thousand Creek stretch over a territory many miles in extent, but the sections examined thus far are not more than a few hundred feet in thickness. The basal strata have not been seen in these exposures. As these beds seem to extend a considerable distance to the north beyond the farthest point thus far examined, it is possible that still lower horizons may yet be found.

The nature of the formation does not vary greatly throughout the region as a whole, and the strata are generally horizontal or only slightly inclined.   There are a few well-marked beds which with careful work might be traced and mapped for a considerable distance.   A sharply defined stratum of white to gray ash in the northern part of the basin resembles an ash layer at the southern end of the field so closely as to suggest their representing the same horizon.

Around the border of the Thousand Creek Flats there are several terraces evidently formed in late Pleistocene time.   The possibility of Pleistocene deposits occurring on these terraces and being confused with an older formation was considered in the field.   With the exception of one or two cases, which are especially considered under the discussion of the fauna, the exposures in which collections were obtained could not be separated from the pre-Pleistocene formation here referred to as the Thousand Creek Beds.

Mammalian fossils have been found in most of the exposures in this region, though they are comparatively rare at some places.   A complete list of the species from the localities about the Thousand Creek Basin is as follows:

Fauna of Thousand Creek Beds

Reptilia.
  Ophidian remains

Aves.
  Branta, sp.

Insectivora.
  Scapanus(?), sp.

Carnivora.
  Tephrocyon, near *kelloggi*, n. sp.
  Canis(?) davisi, n. sp.
  Ursus(?), sp.
  Mustela furlongi, n. sp.
  Mustelid, indet.
  Felis, sp. *a*.
  Felis, sp. *b*.

Rodentia.
  Arctomys nevadensis Kellogg.
  Arctomys minor Kellogg.
  Citellus, sp.
  Aplodontia alexandrae Furlong.
  Mylagaulus monodon Cope.
  Dipoides, sp.
  Eucastor lecontei (Merriam)?.
  Entoptychus minimus Kellogg.
  Peromyscus antiquus Kellogg.
  Peromyscus(?), sp.
  Diprionomys parvus Kellogg.
  Diprionomys magnus Kellogg.
  Lepus vetus Kellogg.

Ungulata.
  Pliohippus(?), sp.
  Equus(?), sp.
  Teleoceras(?), sp.
  Mastodon (*Tetrabelodon ?*, sp.)
  Pliauchenia(?), sp.
  Camel, compare *Camelus americanus* Wortman.
  Prosthennops(?), sp.
  Large suilline form.
  Sphenophalos nevadanus Merriam.
  Ilingoceros alexandrae Merriam.
  Ilingoceros schizoceras, n. sp.

In the collections made in this region thus far no evidence has appeared which indicates definitely a distinct zonal arrangement of the fauna. There are differences between the faunas of some of the localities, but the vertical difference in position of these beds is not great, and the variation may be due to factors other than vertical range.

While the work of collecting was in progress, the question frequently arose as to whether any of the mammalian remains obtained at Thousand Creek were derived from Pleistocene deposits. As has

been stated above, in those cases where the deposits could be examined, there seemed good reason for considering them as all belonging to one formation, while the palaeontologic evidence indicates that this formation is older than Pleistocene.   At one or two localities where loose bones were collected on the broad terraces north of the mouth of Thousand Creek, and along the southwestern border of Thousand Creek Basin, remains of horses were obtained which are not distinctly separable from the genus *Equus*.   The presence of remains referred to *Equus* has suggested that these particular specimens may be derived from Pleistocene deposits resting upon the older beds.   Similar remains are, however, found at other localities where the suggestion of Pleistocene age is not so strong.   There does not as yet seem to be reason for considering that two faunas are mingled in these deposits.   If such mingling occurs the amount of material derived from deposits younger than the Thousand Creek Beds must be very small.

The collections obtained from localities 1096, 1097, 1100, and 1101 are not widely separated geographically, and are from nearly the same horizon, so that they may be taken as a fair representation of the fauna of the Thousand Creek Beds.   The species from these localities include the following forms:

THOUSAND CREEK FAUNA, LOCALITIES 1096, 1097, 1100, 1101

> *Branta*, sp.
> *Canis*(?) *davisi*, n. sp.
> *Ursus*(?), sp.
> *Felis*, sp. *a*.
> *Lepus vetus* Kellogg.
> *Pliohippus*(?), sp.
> *Equus*(?), sp.
> *Teleoceras*(?), sp.
> Mastodon (*Tetrabelodon* ?, sp.)
> Camel, compare *Camelus americanus* Wortman.
> Large suilline form.
> *Sphenophalos nevadanus* Merriam.
> *Ilingoceros alexandrae* Merriam.
> *Ilingoceros schizoceras*, sp.

A number of species of carnivores and rodents not known from the localities mentioned above were obtained at locality 1103, at

approximately the same level as these localities and less than two miles away, on the west side of Railroad Ridge. This collection contained the following species:

Ophidian remains.
Scapanus(?), sp.
Tephrocyon, near *kelloggi*, n. sp.
Mustela furlongi, n. sp.
Mustelid, indet.
Arctomys minor Kellogg.
Citellus, sp.
Aplodontia alexandrae Furlong.
Dipoides, sp.
Entoptychus minimus Kellogg.
Peromyscus antiquus Kellogg.
Peromyscus(?), sp.
Diprionomys parvus Kellogg.
Diprionomys magnus Kellogg.

Although this collection contains no species corresponding to those from the four localities mentioned above, it is noted that the forms present represent an entirely different faunal phase. The genera included in the list from locality 1103 are in some cases types known in the Virgin Valley Beds, as *Tephrocyon* and *Aplodontia*, while others as *Citellus*, *Arctomys*, and *Peromyscus* have a more recent aspect. Considering that there is no reason for presuming this collection to represent an intimate mixture of specimens derived from more than one formation, this phase of the fauna seems to represent approximately the same stage of evolution as that in the list from the first four localities mentioned.

Other genera not found at the four localities first named are *Mylagaulus* and *Prosthennops* (?), found high up in the series at locality 1098.

Relations to Virgin Valley Fauna

COMPARATIVE TABLE OF FAUNAS OF VIRGIN VALLEY AND THOUSAND CREEK

VIRGIN VALLEY BEDS	THOUSAND CREEK BEDS
Reptilia.	Reptilia.
Clemmys, sp.	Ophidian remains.
	Insectivora.
	Scapanus(?), sp.

VIRGIN VALLEY BEDS

Carnivora.
Tephrocyon kelloggi, n. sp.
Tephrocyon(?), compare *rurestris*
(Condon).
Tephrocyon, sp. *a*.
Aelurodon(?), sp.
Probassariscus antiquus matthewi,
n. gen. & n. var.
Felis, sp. *a* (?).

Rodentia.
Aplodontia alexandrae Furlong.
Mylagaulus monodon Cope.
Mylagaulus pristinus Douglass.
Palaeolagus nevadensis Kellogg.
Lepus vetus Kellogg.

Ungulata.
Hypohippus near *osborni* Gidley.
Parahippus, compare *avus*
(Marsh).
Merychippus isonesus (Cope).
Aphelops(?), sp.
Moropus(?), sp.
Mastodon (*Tetrabelodon ?*, sp.)
Merychyus(?), sp.
Camel, near *Procamelus*.
Thinohyus(?), sp.
Blastomeryx mollis, n. sp.
Dromomeryx, sp. *a*, near *borealis*
(Cope).
Dromomeryx, sp. *b*.
Merycodus, near *furcatus* (Leidy).
Merycodus nevadensis, n. sp.

THOUSAND CREEK BEDS

Carnivora.
Tephrocyon, near *kelloggi*, n. sp.
Canis(?) *davisi*, n. sp.
Ursus(?), sp.
Mustela furlongi, n. sp.
Mustelid(?), indet.
Felis, sp. *a*.
Felis, sp. *b*.

Rodentia.
Arctomys nevadensis Kellogg.
Arctomys minor Kellogg.
Citellus, sp.
Aplodontia alexandrae Furlong.
Mylagaulus monodon Cope.
Dipoides, *sp*.
Eucastor lecontei (Merriam)?.
Entoptychus minimus Kellogg.
Peromyscus antiquus Kellogg.
Peromyscus(?), sp.
Diprionomys parvus Kellogg.
Diprionomys magnus Kellogg.
Lepus vetus Kellogg.

Ungulata.
Pliohippus(?), sp.
Equus(?), sp.
Teleoceras(?), sp.
Mastodon (*Tetrabelodon ?*, sp.)
Pliauchenia(?), sp.
Camel, compare *Camelus ameri-
anus* Wortman.
Prosthennops(?), sp.
Sphenophalos nevadanus Merriam.
Ilingoceros alexandrae Merriam.
Ilingoceros schizoceras, n. sp.

From the lists available, it is evident that the faunas of Virgin
Valley and Thousand Creek represent distinct epochs in the evolu-

tion of the mammalia of western North America. Between the times of the deposition of the two series of deposits sweeping changes in the fauna of this region had taken place. The only species known to persist from Virgin Valley to Thousand Creek time are three rodents; two of which, *Aplodontia* and *Lepus*, represent extraordinarily persistent genera. The third form, *Mylagaulus*, has a range from Middle Miocene to Pliocene. The single M_2 of *Tephrocyon* found at locality 1103 does not differ markedly from the corresponding tooth of *T. kelloggi* from Virgin Valley. Other than these species there are no forms which appear to be common to the two series of beds. The mastodon, a large cat, and perhaps some of the camels, may be similar in the two formations, but the material available is not sufficient for specific comparison.

The possible elements common to the Thousand Creek and Virgin Valley Beds are the following, of which the last three are very doubtful and the fourth uncertain.

> *Aplodontia alexandrae* Furlong.
> *Mylagaulus monodon* Cope.
> *Lepus vetus* Kellogg.
> *Tephrocyon*, near *kelloggi*, n. sp.
> *Felis*, sp. *a* (?)
> Mastodon (*Tetrabelodon ?*, sp.)
> Camelid(?)

The ungulates may presumably be fairly taken as a basis for comparison of the two faunas, inasmuch as they include a large percentage of the species known, and are, moreover, the most abundantly represented among the specimens collected in the two regions. In this group we find *Hypohippus*, *Parahippus*, *Merychippus*, *Moropus*, *Merychyus*, *Dromomeryx*, *Blastomeryx*, and *Merycodus* of the Virgin Valley fauna entirely unrepresented in the Thousand Creek Beds. At Thousand Creek horses of the *Pliohippus* type are the common forms; the only other remains of this group known are the few tentatively referred to *Equus*. Among the artiodactyls a small dicotyline from Thousand Creek seems to be generically different from the only remains found in Virgin Valley referable to the Suidae in the wider sense. The large camels, which are among the most common fossils at Thousand Creek, seem not to be represented at Virgin Valley. *Ilingoceros*, the peculiar twisted-horned antelope of Thousand Creek, and *Sphenophalos*, the Antilo-

capra-like form occurring with it, have not been discovered in any of the Virgin Valley collections.

The difference between the faunas of Virgin Valley and Thousand Creek is so wide that a very considerable period must have elapsed between the times of deposition of these two sets of beds. It seems scarcely possible that the changes here indicated could be quantitatively less than those which took place between the Middle Miocene and the Pliocene of well-known regions, or that the time period represented could be less than that occupied by the Upper Miocene stage of evolution of the mammalia.

General Relationships of Thousand Creek Fauna.—Among the various assemblages of mammalian forms known in America the fauna of Thousand Creek is unique. Its closest relationships are apparently with Pliocene faunas as represented by the mammalia of the Snake Creek and Blanco, but to neither of these does it correspond closely.

As has already appeared, only a limited number of the Thousand Creek generic types, and a smaller number of the species occur in the Middle Miocene fauna of Virgin Valley, while the presence of such ancient genera as *Tephrocyon*, *Mylagaulus*, and *Teleoceras* excludes the possibility of referring the Thousand Creek fauna to a period as late as even the earliest Pleistocene.

The number of Thousand Creek species appearing in the Snake Creek fauna is slightly larger than that found in any other known assemblage of mammalian forms in America. The list of forms common to the two includes the types *Tephrocyon*, *Mustela*, *Felis*, *Mylagaulus*, *Dipoides*, *Pliohippus*, and presumably *Teleoceras*. The camels and mastodons are also not improbably closely related. These two faunas are the only ones in America known to include antelopes suggesting close relationship with the typical Old World forms. In spite of a partial resemblance, the Thousand Creek fauna differs distinctly from that of Snake Creek in the absence of all representatives of *Hypohippus*, *Parahippus*, *Merychippus*, *Merychyus*, *Blastomeryx*, and *Merycodus*, the horses being represented by *Pliohippus*, possibly accompanied by *Equus*, and the boöid artiodactyls by previously unknown types of antelopes. There seems no question but that the Thousand Creek fauna is younger than that of Snake Creek, though evidently as near to the Snake Creek stage as to any other recognized horizon in America.

The Blanco Pliocene fauna of Texas resembles that of Thousand Creek in the absence of horses below the stage of *Protohippus* and *Neohipparion*. Unfortunately the Thousand Creek camels and mastodons are not well enough known for a thoroughly satisfactory comparison. In the disappearance of rhinoceroses, mylagaulids and tephrocyons, and in the appearance of several southern types of edentates the Blanco stage is more advanced than that of Thousand Creek.

In so far as correlation with the American mammalian faunas is concerned the Thousand Creek fauna would seem necessarily to take a place later than that of the Snake Creek and earlier than that of the Blanco. With this arrangement it seems probable that the Snake Creek fauna can hardly be considered as later than early Lower Pliocene, verging on the Miocene. The Thousand Creek fauna may be included in the lower Pliocene, but must represent a late stage of this division. The Blanco fauna is presumably considerably later than that of Thousand Creek. Though the variation may be due in part to geographic and climatic differences, it is hardly probable that if the Thousand Creek fauna represents the late Lower Pliocene the Blanco can represent a horizon as early as the earliest Middle Pliocene.

RELATIVE AGE OF VIRGIN VALLEY AND THOUSAND CREEK FAUNAS, ACCORDING TO GENERAL CORRESPONDENCE AND STAGE OF EVOLUTION

Middle Pliocene		Blanco
Lower Pliocene	Thousand Creek	Snake Creek
Upper Miocene		Santa Fe and Madison Valley
Middle Miocene	Virgin Valley	Mascall, Deep River, and Pawnee Creek

Relation of Thousand Creek Fauna to its Environment.—The deposits formed during the Thousand Creek epoch are not characterized by lignitic beds or carbonaceous shales as in the Virgin Valley section, nor have water-laid deposits containing abundant plant

remains been recognized. The deposits do, however, contain scattered bones of small fishes in at least one locality examined, and were evidently in some part formed in standing water. Some of the material is volcanic ash which accumulated rapidly. Another portion is made up of beds which resemble soil accumulations, to which additions may have been made by dust or fine ash deposits.

From the character of the Thousand Creek Beds taken by themselves there is little to indicate the nature of the climatic conditions that obtained in this region while they were being deposited. So far as the evidence at hand may be interpreted, there seems no reason for presuming that the conditions at that time differed far from the possible range of environment within the Basin region at the present time. The degree of humidity may have been slightly higher than to-day, but the evidence favoring this view is derived mainly from the character of the fauna. Presumption is in favor of the view that the degree of humidity was less than during the deposition of the principal mammal beds in Virgin Valley.

The distribution and stratigraphic relations of the Thousand Creek Beds so far as known suggest that the topography of the region in this epoch resembled an advanced stage in the evolution of the topography begun in Virgin Valley time. Considerably elevated regions still existed, but around these the deposits had been built up till many of the minor irregularities had been completely buried, and a much wider expanse of level country was presented. According to any interpretation which may be put upon the depositional history of this region we must consider that the extent of plains territory here during Thousand Creek time was approximately as great as that of the wide stretches of level land in the great valleys of the Basin region at the present time.

In the mammalian fauna, the ungulates of the Thousand Creek Beds represent in general types somewhat better adapted to a plains region than was the fauna of the Virgin Valley epoch. The only horses present are *Pliohippus*, and possibly *Equus*, with well-developed prismatic crowns of the molar teeth, while the only boöid artiodactyls are antelopes with long-crowned molars.

That the fauna of the region was not limited entirely to open and semi-arid plains is suggested by the presence of a goose (*Branta*), a mole (*Scapanus*), and a possible representative of *Ursus*. Among the rodents the sewell (*Aplodontia*) was presumably a dweller in a

moist region with abundant vegetation. *Arctomys* is not a characteristic plains form, but might have lived on the borders of open country.

The mammalian fauna as a whole suggests plains with occasional lakes or meadows bordering rugged or elevated areas. The degree of humidity may have been somewhat greater, and vegetation more abundant than at the present time. The presence of *Arctomys* may suggest a slight cooling of the climate, either due to general climatic changes, or to elevation of this region.

General Correlation of Virgin Valley and Thousand Creek Beds on the Basis of Physical and Faunal Relationships to Other Formations of the Pacific Coast Region

Such reference to correlation of the formations of northern Nevada as has appeared in this discussion up to the present time has been based upon either stratigraphic or faunal evidence considered alone. It seems important to consider the relation of these formations to each other, and to other members of the Tertiary system in the Pacific Coast region in the light of the combined evidence from these fields of investigation, in order to see the fragments of the palaeontologic record placed as nearly as possible in their true relative positions. In further discussion it is desirable to use all of the available means of comparison checked against each other, in the hope that thus combined they may ultimately accomplish more than has been possible with any one group alone.

Relation of Virgin Valley and Thousand Creek Beds to each other.— In the discussion of the geologic relations of the Thousand Creek Beds, in Part I of this paper[7] the writer has indicated the difficulties in the way of determining the exact geologic relations of the Virgin Valley and Thousand Creek formations to each other without farther study of this region. An investigation of the territory to the north and east would probably furnish the information necessary to make clear the doubtful factors in the physical history.

The palaeontologic relations of the two formations seem pretty clearly defined. While the writer has constantly held in mind the possibility that a mixture of Miocene and Pleistocene species might result in a determination of the age of the Thousand Creek Beds as

[7] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 45–50, 1910.

Pliocene, the evidence before us does not seem to indicate that this is the case.   A Miocene fauna such as that of Virgin Valley does not seem to be represented in the Thousand Creek collections, though a few of the Virgin Valley species are present.   In the horse group the presence of *Pliohippus* and the absence of the Virgin Valley *Hypohippus*, *Parahippus*, and *Merychippus* seem to exclude the Middle Miocene, the Pleistocene, and probably also the Upper Miocene. Among the boöid artiodactyls, the presence of the peculiar antelope forms *Ilingoceros* and *Sphenophalos*, not known in the Virgin Valley Beds, and unknown in the abundantly represented Pleistocene faunas of the Pacific Coast region, together with the absence of *Dromomeryx*, *Blastomeryx*, and *Merycodus*, again indicates that the Thousand Creek Beds represent a stage distinctly later than the Middle Miocene and earlier than Pleistocene.

The physiographic history of the Thousand Creek region as indicated in the terrace levels bordering the valley, leads one to suspect that Pleistocene deposits might be present, and that mammalian remains derived from them could be mingled with those from the underlying Pliocene beds.   As has been indicated in the preceding discussions, no definite suggestion as to such mingling has been offered, excepting in the case of a few specimens, especially certain remains of an Equus-like form obtained from some of the terraces.   The same form occurs, however, at another locality where rhinoceros remains seemed to be present with it.

It will not be surprising if future observations show that a Pleistocene fauna is represented at Thousand Creek.   With the evidence at hand it does not appear that the question as to the age of the extensive exposures recognized as the Thousand Creek Beds, and containing a fauna including *Protohippus* and rhinoceroses, is seriously complicated by such remains as are doubtfully Pleistocene.

As was indicated in the discussion of the physical history of the Virgin Valley and Thousand Creek region in Part I of this paper the possibilities as to age of the Thousand Creek Beds with relation to the Virgin Valley Beds appear to be as follows.   The Thousand Creek Beds may be:

(1) Upper Virgin Valley Beds, faulted down.

(2) Post-Virgin Valley and pre-Mesa-Basalt, faulted down.

(3) Post-Mesa-Basalt; formed from older wash of Virgin Valley, faulted down.

(4) Post-Mesa-Basalt; formed from younger wash of Virgin Valley, not moved far by faulting.

(5) Composite, partly Virgin Valley and partly Pleistocene.

When checked by what we know of the faunal relationships of the Virgin Valley and Thousand Creek Beds, it is noted that the interval between the Virgin Valley and Thousand Creek faunas seems to amount to a period at least as long as the Upper Miocene, and that the Thousand Creek Beds cannot be later than early Pliocene. This would make it improbable that the Thousand Creek Beds belong to the same period of deposition as the Virgin Valley. On the other hand it seems improbable that the cutting of the present cañon of Thousand Creek was well under way before the beginning of Pliocene time. These suggestions seem to narrow the problem down to the following possibilities:

(1) That the Mesa Basalt is Miocene in age and that the present cañons began to cut in early Pliocene time, the Thousand Creek Beds being formed by the accumulations of early wash from this erosion.

(2) That the Thousand Creek Beds represent a pre-Mesa-Basalt formation of considerably later age than the principal mammal zone of the Virgin Valley Beds.

According to the first view the Thousand Creek Beds are post-Mesa-Basalt in age, and were accumulated during the cutting of Virgin Valley or other valleys of approximately the same age. There are several arguments which may be put forward in support of this view, but it seems especially desirable to have more evidence regarding the relation of the northern and western extensions of the Thousand Creek Beds to the Mesa Basalt before it can be seriously considered.

The second view postulates the pre-Mesa-Basalt age of the Thousand Creek Beds and makes them either the equivalent of the uppermost portion of the Virgin Valley section or a pre-Mesa-Basalt accumulation formed from the erosion of the Virgin Valley and not represented in the portion of the Virgin Valley section examined. The fact that the upper portion of the Virgin Valley section seems to be separated from the middle zone by an unconformity below the rhyolitic gravels lends some support to this view. If, as seems to be the case, the unconformity below the rhyolitic gravels in Virgin Valley is not due to accumulation during the cutting of the

present valley; and if this unconformity is not a purely local dis-
cordance due to extraordinary stream action in Virgin Valley time,
then there is reason to consider the Virgin Valley as divisible into
two periods of sedimentation which may have been separated by a
considerable epoch of erosion.

The Thousand Creek Beds may correspond to that portion of the
Virgin Valley series above the unconformity.   Also if the uncon-
formity should appear to be between typical Virgin Valley Beds and
gravels laid down in the course of the cutting of the valley, the
gravels may correspond to some phase of the Thousand Creek Beds.
So far as these possibilities are concerned, it is important to know
if a fauna similar to that of Thousand Creek can be obtained in the
uppermost portion of the section of Virgin Valley.   As yet nothing
characteristic of either the Virgin Valley or the Thousand Creek
faunal phase has been obtained from this portion of the section.
The only suggestion of evidence has come through the examination
of a number of the low hills in Virgin Valley which seem to be formed
by slides which have come down from the summit of the mesa.   In
this locality mastodon remains seem more abundant than in other
places in Virgin Valley, and the only specimen representing a very
large feline was found here.   At Thousand Creek, mastodon re-
mains are more abundant than at Virgin Valley, and remains of very
large felines are well known.

In order to come to an entirely clear understanding of the true
stratigraphic relations of the Virgin Valley and Thousand Creek
beds it will be necessary to make a further examination of the
geology of this region.   Such evidence as will make perfectly clear
the relation of the biologic succession to the series of events in the
physical history of this region is much to be desired, as the final
understanding of either the biological or the physical history of the
Pacific Coast region can be accomplished only by utilizing all evi-
dence which can be obtained.   A clear understanding of the relation
of the physical and biologic successions to each other will often
make possible the bringing together in intelligible form of evidence
otherwise entirely without meaning.

*Relation of Virgin Valley Beds to the Middle Miocene Formations
of the Pacific Coast and Basin Regions.*—As has been set forth in
Part I of the present paper,[8] the Virgin Valley Beds rest upon a

[8] Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 26–30, 1910.

floor of older igneous rocks, which apparently correspond to the upper portion of a great series of basalts and rhyolites to which the tentative name of Pueblo Range Series has been applied. This igneous series has been traced to the north by Waring,[9] and is considered by him to represent a southward extension of the great lava flows along the Columbia River. The complete section from southern Oregon to the typical region of the Columbia Lava has not been actually traced, and it is most desirable that the connection should be carefully worked out. There are, nevertheless, strong reasons for considering with Blake and Waring that the eruptive series of southern Oregon is only a part of the series of flows which cover such an enormous extent of territory farther to the north, and certain suggestions as to broader correlations may tentatively be based upon this supposition.

It is well worth noting that the relation of the Virgin Valley Beds to the older rocks referred to the Pueblo Range Series as determined on purely physical evidence is approximately the same as the relation of the Mascall Beds of the John Day region to the Columbia Lava; while on the basis of the similarity of mammalian faunas the Mascall and Virgin Valley are considered as representing the same epoch, viz., the Middle Miocene. The biological and physical relations considered together seem to indicate pretty clearly that we are dealing with the same stratigraphic sequence in the two regions.

The relation between the Columbia Lava and the Middle Miocene sedimentary formations containing a characteristic mammalian fauna seems to be one of unusual importance for correlation purposes. In no other region, and at no other geologic horizon, do we know a series of igneous outflows exceeding in magnitude and in areal extent the Miocene lavas in and contiguous to the Columbia River area. For purposes of reference in correlation this series would seem to furnish a most important datum plane wherever it can be traced, or wherever recognized by any petrographic peculiarities.

Following the deposition of the early Miocene lava flows, conditions favorable for the accumulation of sediment obtained in many areas over the lava-covered regions, and extensive deposits were formed, of which presumably a large part have since disappeared

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[9] Waring, G. A., U. S. Geol. Surv. Water Supply, 231, p. 2, 1909.

through erosion; but patches and even extensive areas have remained in many places. During this period the rich and varied mammalian fauna would presumably distribute itself with unusual uniformity over the wide stretch of territory which had been occupied in the period immediately preceding by the great lava flows. It is to be presumed that the large lava areas, covering more than 250,000 square miles, would permit a particularly wide distribution of certain forms at that time. Though the lava beds appear to have been subjected to disturbance in some regions, the amount of movement was probably not sufficient to raise barriers which would offer important obstacles to the distribution of most mammalian forms. Judging by what we know of the mammalian faunas referred to the Middle Miocene of the West-American province, there was actually a notable uniformity in the life over this region during this epoch.

The distribution of the Miocene flows which seem to be related to the great sheets poured out in the Columbia River region has not been determined with exactness. Nevertheless one seems to be justified in certain suggestions as to the probable extension of this field to the north and south of the Columbia.

To the north of the Columbia, the lavas seem to be traced with certainty in eastern Washington, and upon them is found a sedimentary series known as the Ellensburg formation, which resembles in its general character the Mascall of Oregon. Such fossil remains as have been reported from these beds, particularly the plants, correspond to those of the Mascall.

To the south of the Columbia, the lava fields extend around the Blue Mountains and cover the Oligocene John Day formation. In the valley of the John Day River near Dayville the Mascall Beds lie in a trough formed by the Columbia Lava faulted down against the older formations on the northern flank of this portion of the mountain mass. On the summit of the mountains the Columbia Lava appears again dipping gently to the south, where it seems to disappear beneath a formation resembling the Mascall. These beds contain a mammalian fauna similar to that in the Mascall on the northern flank of the mountains.

To the south of the Blue Mountains lies the extensive lava region in which the basaltic flows have been compared by Waring and others to the Columbia Lava, and upon a southern extension of an

igneous series comparable to these flows rest the Virgin Valley Beds with a fauna similar to that of the Mascall.

It does not seem to the writer to be an absolutely safe conclusion that all of the igneous rocks included in the flows to which reference has been made are necessarily the exact equivalent of the main exposures on the Columbia River, or to this series as limited to the basalt flows which lie between the John Day Upper Oligocene and the Mascall Middle Miocene. Other igneous series both earlier and later are known, but there is a reasonable presumption in favor of considering the group of flows to which reference has just been made as belonging to the same general epoch. This epoch on the basis of correlation by mammalian palaeontology is referable to the Lower Miocene, as the beds immediately below it contain an Upper Oligocene fauna and those immediately above it a Middle Miocene fauna.

To the south of the Virgin Valley area in Nevada, the broken structure of the Basin region makes difficult the tracing of formations which are not quickly recognized by palaeontologic or petrographic species. There are, however, in this region exposures of beds which have superficially the appearance of the Miocene formations farther north, and which contain scattering remains of mammalian forms apparently later than early Miocene and older than Pleistocene. Exposures of this nature extend well through the state of Nevada, and may reach into the southern part of California. It is probable that a careful study of the patches of sedimentary deposits extending through Nevada and into California will enable us to arrive at an approximate correlation of these formations.

As a few mammalian remains are found in the deposits of Tertiary age within the Great Valley of California it is hoped that correlation of these beds with the continental deposits of the Basin region may ultimately be possible. When this is accomplished we can determine the relationship of the continental beds to the well-known marine series of the Pacific Coast region.

The relation of the Columbia Lava series to the marine beds of Western Oregon should also furnish important information in any effort which may be made to correlate the continental formations with the marine series.

Relation of Virgin Valley Beds to Faulting Movements of Basin Region.—As nearly as can be determined, the Virgin Valley Beds

rest unconformably upon the Cañon Rhyolite in Virgin Valley. There is reason to believe that these rhyolites represent the upper portion of the igneous series of Pueblo Range, and any disturbance which affected the rhyolites must have disturbed this basalt series. It is evident that considerable faulting movements have affected the basaltic series in comparatively late time, and other movements may have occurred between the Virgin Valley and Thousand Creek epochs. The amount and nature of these movements cannot be determined until the relation of the Virgin Valley and Thousand Creek Beds to each other is certainly known. If the Thousand Creek Beds were formed in post-Mesa-Basalt time and all of the beds below the Mesa Basalt are to be referred to one epoch, the Virgin Valley, there must have been profound movements in pre-Virgin-Valley time, as the sediments below the Mesa Basalt have filled around prominent points consisting of the older igneous rocks. If the beds immediately below the Mesa Basalt are the equivalent of the Thousand Creek series, it is possible that considerable movements occurred after the deposition of the Virgin Valley and previous to the deposition of the uppermost beds. The presence of a marked unconformity below the rhyolitic gravels, which possibly separate upper and lower Virgin Valley divisions, is in favor of such a view. On the other hand, excepting at the contact below the rhyolitic gravels there does not appear to be a noticeable difference in position between the upper and lower sedimentary beds below the Mesa Basalt; at any rate no such difference appears as would be produced if any considerable change in the topography had developed through faulting or other movements.

On any hypothesis excepting that the Thousand Creek Beds were formed by accumulation late in the history of the cutting of Virgin Valley, it would be impossible to avoid the conclusion that important faulting movements have occurred in this region in post-Thousand-Creek time.

Relation of Thousand Creek Beds to other Formations of the Pacific Coast and Basin Regions.—The unique character of the mammalian fauna found in the beds at Thousand Creek, and the imperfectly understood stratigraphic relations of the formation in which this fauna occurs make it difficult to estimate the position of the Thousand Creek Beds in the scheme of Pacific Coast formations. A possible relationship to the Rattlesnake Beds of the John Day region

in Oregon is the correlation which naturally suggests itself before any other. Correlation with other formations is also suggested, but the basis for comparison is very slight.

The type exposure of the Rattlesnake fortunately occurs in the same region with the typical section of the Mascall Miocene, and with well-marked Pleistocene deposits, so that the earlier and later limits of age of the Rattlesnake are quite clearly defined.

The typical Rattlesnake Beds rest in marked unconformity upon the Mascall along the border of the Blue Mountains in the vicinity of Dayville on the John Day River. The Mascall here occupies a trough formed on the north side by the Columbia Lava dipping to the south, and on the southern side by the mass of the Blue Mountains, the Columbia Lava being faulted or sharply folded against the northern side of this ridge of the mountains. The Mascall Beds agree in dip and strike, so far as observed, with the underlying Columbia Lava, and were deposited previous to the movement expressed in the sharp deformation of the lava. As the exposures of the Mascall are between 1,000 and 2,000 feet thick, and are seen in the narrow trough because of deformation of the underlying lava since their deposition, it is evident that they originally existed outside this depression, but have been eroded away. The Rattlesnake rests in a very slightly inclined position upon the eroded edges of this steeply tilted Mascall, and it is clear that the time of beginning deposition of the Rattlesnake must have been separated from the closing of deposition of the Mascall by a period in which very marked deformation and extensive erosion of the Mascall occurred. It seems improbable that this deformation and erosion could have taken place in a period shorter than that represented by the Upper Miocene. This being the case the Rattlesnake would not be older than early Pliocene.

The upper limit of age of the Rattlesnake seems to be fixed by the beginning of the erosion period during which the great cañons of this region were cut. Terrace deposits near the floor of the present cañon of the John Day River contain undisturbed remains representing a Pleistocene fauna. The cañon-cutting period must, therefore, have ended sometime before the close of Pleistocene time. The presumption is that the cañon-cutting was accomplished in early Pleistocene time. As the John Day Cañon cuts through the typical Rattlesnake section, the upper limit of age of these beds seems determined as not later than the beginning of the Pleistocene.

The Rattlesnake Beds as we know them in the John Day Valley were evidently laid down in a basin of comparatively limited extent, which was bounded on the north by the Columbia Lava monocline, and reached south to the ridge of the Blue Mountains south of the John Day River. The greatest thickness of the beds known to the writer, including the maximum thickness of the various members of the series, would be a little less than 500 feet. A small part of the series consists of beds which have the appearance of old soil mantles, but the greater portion of the whole accumulation is made up of coarse gravel. The time required for the deposition of the whole thickness may, therefore, have been rather short, and presumably does not represent more than one-half of the Pliocene, in which it seems probable that the formation of this series of beds occurred. There does not, however, seem to be anything in the physical evidence to indicate whether the deposition occurred in early or in late Pliocene time.

The only suggestion bearing upon the question as to the division of the Pliocene represented by the Rattlesnake Beds is offered by the fauna. The few species thus far found at the Rattlesnake exposures are unfortunately only poorly represented, and in a large percentage of cases the occurrence is not known exactly. Following is the list of species referred to this formation:

> *Neohipparion occidentale* (Leidy)
> *Neohipparion sinclairi* (Wortman).
> *Platygonus rex* Marsh.
> *Pliohippus supremus* (Leidy).
> *Canis*(?) *davisi* Merriam?.
> *Clemmys hesperia* Hay.
> Rhinoceros, indet.
> Camel, large, indet.
> Camel, small, indet.
> Suilline, large, indet.

Of the above forms the rhinoceros seems quite certainly not later than the earlier Pliocene, so that taking all evidence into consideration an approximation of the age of the Rattlesnake as early Pliocene seems justified.

Judging the age of the Thousand Creek and Rattlesnake Beds separately on the basis of available information, both seem to fall within the Lower Pliocene. The meagre Rattlesnake fauna offers so little for comparison that faunal similarity between the two is not

evident. The only parallels indicated are shown in the occurrence in both of rhinoceroses and large camels, together with horses having an advanced type of tooth structure. An additional suggestion appears in the presence in the Thousand Creek Beds of the canid species, *Canis* (?) *davisi*, which seems to be identical with a species doubtfully derived from the Rattlesnake at Rattlesnake Creek, Oregon.

In the region where the Thousand Creek Beds are exposed there are fortunately two important factors in the geologic sequence which seem to be almost identical with the physical factors which check the possible upper and lower limits of age of the Rattlesnake Beds in the John Day Valley; these factors are (1) the Virgin Valley beds, corresponding to the Mascall; and (2) the great valleys originating, like the valley of the John Day, through geologically recent erosion. If the relation of the Thousand Creek Beds to both of these factors were clearly shown, important evidence would be available for checking the relative ages of the two formations.

If the Thousand Creek Beds are pre-Mesa-Basalt, as seems possible, they may correspond closely in age to the Rattlesnake. It is perhaps worth noting that the remarkable extent of the layer of Mesa Basalt in the Virgin Valley region is paralleled, in a manner, by the great extent of the bed of Mesa Rhyolite, forming the mesa capping over a considerable part of the Rattlesnake.

If the Thousand Creek Beds are post-Mesa-Basalt they are either younger than the Rattlesnake or the cañon-cutting was initiated at an earlier date than in the region to the north of the Blue Mountains. As nearly as we are able to judge there seems reason to believe that the great cañons of the entire region under consideration owe their origin to an uplift of continental character, which occurred near the close of Pliocene time, and unless special conditions have been introduced in one or the other of the regions discussed we are presumably near the truth in considering the cañon-cutting as nearly coincident in the two areas. In that case post-Mesa-Basalt age of the Thousand Creek Beds would place them at a much later date than the Rattlesnake. It would also evidently place them within the limits of Pleistocene time, which is clearly negatived by their fauna. It seems, therefore, that with the evidence at hand there is reason for considering the Thousand Creek Beds as pre-Mesa-Basalt.

As will be seen, the lines, however drawn, seem to indicate that the Rattlesnake and Thousand Creek epochs are nearer to each other than either is to any other distinctly recognized epoch in the history of this region. There is, however, still reason for considering them as not necessarily identical. Such faunal evidence as is available does not by any means indicate contemporaneity, and the physical evidence of contemporaneous deposition is far from definite. It seems probable that additional palaeontologic and geologic studies in both regions may ultimately give us a much more satisfactory statement of the relations than is now possible.

Of the formations in which mammalian fossils have been found west of the Sierra Range region there are none in which a sufficient representation is known to offer more than a mere suggestion as to time relationship to the Thousand Creek Beds. Four formations in California—the Pinole Tuff and Orindan freshwater formations of the San Francisco Bay region, and the largely marine Jacalitos and Etchegoin formations of the western San Joaquin Valley— contain fragmentary mammalian remains which suggest a late Miocene to Pliocene stage.

The Pinole Tuff, overlying the San Pablo formation at San Pablo Bay, contains a few fragmentary mammalian fossils, among which is a horse of an advanced protohippine type. The type of horse present here might represent late Miocene or early Pliocene. It is of a stage at least as advanced as that of the *Pliohippus* species found at Thousand Creek.

In the Orindan and Siestan formations which overlie the Pinole Tuff a few remains have been found at rather widely separated localities. They include a large mastodon, a species of *Neohipparion* near *N. richthofeni*, a small camel, a peccary, and the type specimen of *Eucastor lecontei*. This fauna would seem to represent a very late Miocene or early Pliocene stage, but occurs above the Pinole Tuff with *Pliohippus*.

In the Jacalitos formation of the western San Joaquin Valley, as also in the Etchegoin formation above it, scattered horse teeth have been found representing a species of *Pliohippus* about as advanced as that of the Pinole Tuff. Taken by itself, this form would be considered as representing late Miocene to Pliocene time.

The stages of evolution represented by the protohippine forms of the Pinole Tuff and the Etchegoin formation are approximately

the same, so far as can be determined with the very fragmentary material at hand. They are also at approximately the stage of advance shown in the Thousand Creek species. This may, however, not be taken as suggesting more than that these California formations are to be included in a period covered by the late Miocene and early Pliocene. They all belong in an epoch which follows the middle Miocene and precedes the middle Pliocene. Further collections from the Californian formations will doubtless assist in determining their relationship to the Thousand Creek Beds more definitely.

SYSTEMATIC DESCRIPTIONS

Pisces

Scattered vertebrae and isolated skull bones of small fishes were found at locality 1090 in the Virgin Valley Beds, and at locality 1097 in the Thousand Creek Beds. The material was very fragmentary and a satisfactory determination of the forms represented seems improbable.

1a   1b

Figs. 1a and 1b. Ophidian remains. Precaudal vertebrae. No. 19422, × 2. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 1a, posterior view; fig. 1b, lateral view.

Reptilia

OPHIDIAN REMAINS

Several snake vertebrae were found in an exposure of the Thousand Creek Beds west of Railroad Ridge. They evidently belong to several individuals, and it is not certain that they all represent the same generic type. The vertebrae present are pre-caudals with well-marked rib attachments (see figs. 1a and 1b). The imperfect development of the neural spines is presumably to be attributed to their having been located near the posterior portion of the rib-bearing division of the vertebral series. The zygosphene is large and the zygantral excavation deep. Hypapophyseal prominences are present, but are imperfectly developed.

Occurrence: Thousand Creek Beds; locality 1103, Thousand Creek region, west of Railroad Ridge, Humboldt County, Nevada.

CLEMMYS, sp.

A number of fragments representing testudinate forms (fig. 2) from locality 1090 in the Virgin Valley Beds were referred to Dr. O. P. Hay for examination. Dr. Hay has very kindly furnished the following statement regarding these specimens: "I examined the pieces of turtles sent me and compared them especially with *Clemmys marmorata* from California. I see no reason why they may not belong to that genus, but they certainly are not *C. marmorata*. The material is so scanty that it seems to me better not to describe it, or at least not to name it."

Occurrence: Virgin Valley Beds; locality 1090, Virgin Valley, Humboldt County, Nevada.
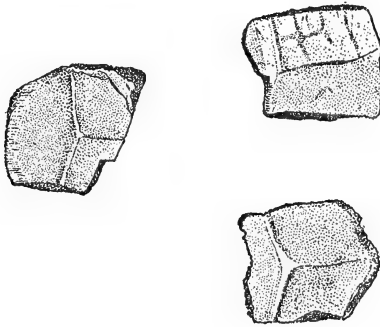

Fig. 2. *Clemmys*, sp. Peripheral elements. No. 19421, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

AVES

BRANTA, sp.

At two localities several miles apart in the Thousand Creek region, fragmentary specimens representing the ulna of a large species of goose (fig. 3) were found. These specimens were examined by Mr. L. H. Miller who has kindly furnished the following note regarding them.

"No. 12556 is the distal portion of the left ulna of a large anserine bird corresponding most closely in size with the Recent *Branta canadensis*. The fossil specimen slightly exceeds in size the only specimen of the Recent form available for comparison, but the difference is scarcely greater than exists within the range of the species as it is known today. There is no character that would

exclude the specimen from the species *Branta canadensis* Linn. (?), although in the absence of a more complete specimen its assignment to this species must be a purely tentative procedure."

The second specimen is identical in form with the one described above by Mr. Miller, and is considered by him as representing the same species.

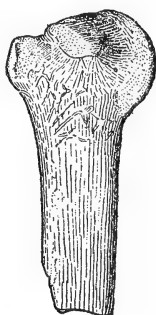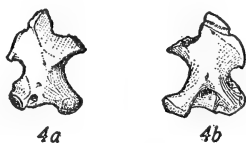Occurrence: Thousand Creek Beds; localities 1063 and 1100, Thousand Creek, Humboldt County, Nevada.

FIG. 3. *Branta*, sp. Distal portion of left ulna. No. 12556, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

4a 4b

FIGS. 4a AND 4b. *Scapanus*(?), sp. Right humerus. No. 19409, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 4a, anterior view; fig. 4b, posterior view.

INSECTIVORA

SCAPANUS(?), sp.

From two localities in the Thousand Creek region remains representing moles have been obtained. The only specimens recognized thus far consist of the humeri (figs. 4a and 4b), which do not seem to furnish characters clearly distinguishing them from the existing moles of the West Coast region. It is not improbable that more material would show peculiar generic characteristics in the Thousand Creek forms. The presence of moles at two localities in the Thousand Creek Beds seems to indicate a soil more humid at these localities than the average soil in this region at the present time. This

may, however, be due to purely local conditions of humidity, such as obtain at the present time in restricted areas of the Great Basin region.

Occurrence: Thousand Creek Beds; localities 1103 and 1097, Thousand Creek, Humboldt County, Nevada.

CARNIVORA

CANIDAE

TEPHROCYON KELLOGGI, n. sp.

Type specimen a lower jaw with dentition, no. 11562, Univ. Calif. Col. Vert. Palae. From the Virgin Valley formation at Virgin Valley, Humboldt County, Nevada. The species is named in honor of Miss Louise Kellogg, who discovered the type specimen.

The genus *Tephrocyon* is represented by several specimens referred to a species distinct from the typical *T. rurestris* of the Mascall formation in the John Day region of Oregon. Through the kindness of Professor John F. Bovard and Professor Arthur J. Collier, the type specimen of the Mascall species was loaned by the University of Oregon for comparison.

The jaw is of nearly the same length as in the type species, but more slender and the inferior margin not so strongly convex below the anterior end of the masseteric fossa. Inferior pre-molar series longer, and molar series shorter than in *T. rurestris*. P_1, P_2, and P_3 of the type specimen without anterior or posterior cusps. P_4 with a single posterior cusp. M_1 with large metaconid, heel with large crushing hypoconid and entoconid. Trigonid of M_2 with well-developed paraconid.

The form of the mandible (pl. 32) in this species differs less noticeably from that of the typical *Canis* than in the type specimen of *Tephrocyon*. The inferior margin is not as strongly convex as in *T. rurestris*, nor is the jaw as a whole quite as massive. The jaw tends, however, to be relatively heavy in the posterior half in comparison with species of *Canis*.

The incisor teeth are not present on any specimen, and the canines are represented only by the basal portion of a tooth not showing any peculiar characters.

The premolars are uncommonly simple in form on the type specimen of this species. There appear to be no subsidiary cusps

on the first three premolars, but P_4 has in addition to the principal cone a posterior cusp and an incipient basal tubercle. On another specimen, no. 11474, apparently representing this form, P_2 has a distinct posterior cusp.

M_1 is characterized by the large size of the metaconid and of the broad crushing heel (see pl. 32, fig. 1). The metaconid is larger and more prominent than in *T. rurestris*. The heel of this tooth is nearly identical in form with that of the type species. The hypoconid and entoconid are of approximately equal size, but the entoconid seems to be slightly more elevated. There is a small but
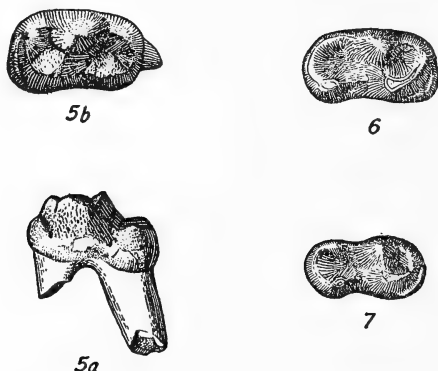
FIGS. 5a AND 5b. *Tephrocyon kelloggi*, n. sp. M_2, unworn tooth. No. 10651, × 1½. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 5a, outer side; fig. 5b, superior side.

FIG. 6. *Tephrocyon kelloggi*, n. sp. M_2, worn tooth. No. 11474, × 1½. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 7. *Tephrocyon*, near *kelloggi*, n. sp. M_2. No. 12542, × 1½. Thousand Creek Beds, Thousand Creek, Nevada.

distinct tubercle on the posterior side of the base of the protoconid immediately in front of the hypoconid. Another small tubercle is faintly developed on the posterior side of the base of the metaconid.

M_2 is relatively large, and an extraordinarily developed tooth. Its fore and aft diameter equals almost three-fourths that of the carnassial, and there is a well-developed paraconid present. The protoconid and the metaconid are nearly equal in size. The paraconid may nearly equal the other cones in size. On the large basin-shaped heel the nearly equally developed hypoconid and entoconid are connected posteriorly by a low marginal ridge. On the antero-external side of the base of the trigonid a prominent ridge is devel-

oped on the cingulum.   On the specimens available a minute tubercle is present in the valley between the protoconid and hypoconid.

M_3 is not represented on any of the specimens.   Judging from the form and size of the alveolus, this tooth was relatively large, and its anteroposterior diameter was considerably greater than the transverse.

MEASUREMENTS

	Type specimen, no. 11562
Length of mandible from anterior side of P_1 to posterior side of condyle. .	103.7 mm.
Height of mandible below protocone of M_1.	21.
Greatest thickness of mandible below talonid of M_2.	9.
P_2, anteroposterior diameter.	6.
P_3, anteroposterior diameter.	6.7
P_4, anteroposterior diameter.	8.4
M_1, anteroposterior diameter.	15.
M_1, anteroposterior diameter of heel.	4.
M_1, transverse diameter of heel.	7.
M_2, anteroposterior diameter.	10.5
M_2, greatest transverse diameter.	6.7
	No. 10651
M_2, anteroposterior diameter.	11.5 mm.
M_2, greatest transverse diameter.	6.9

In its most distinctive characters, that is in the form of M_1 and M_2, this species resembles the typical *Tephrocyon*, and is evidently closely allied to it.   It differs from the type species in the simpler premolars, larger metaconid of M_1, and relatively larger M_2.   The simplicity of the premolars, if found to occur regularly in a large series of specimens, might, taken with other differences, be advanced as evidence of subgeneric separation.   It should, however, be noted that on one specimen, no. 11474, a distinct posterior cusp is developed on P_2, though the dentition is otherwise quite similar to the type specimen of *T. kelloggi*, and there seems hardly sufficient reason for specific separation.

The characters of the dentition in *Tephrocyon* as represented in *T. kelloggi* are in some respects quite bear-like.   The second molar is unusually large, its anteroposterior diameter equalling over seventy per cent of that in M_1.   The anteroposterior diameter of M_2 nearly equals that of the corresponding tooth in *T. rurestris*, while in that species the carnassial is one-third larger than in *T. kelloggi*.   In the carnassial the large heel and the extraordinarily

developed metaconid give an unusual crushing surface. Judging from the size of the alveolus M_3 was relatively larger than in *T. rurestris*.

Such ursine characters as appear in the dentition of this form are probably not to be considered as indicating that it is in any sense ancestral to the bears. The great variety of canids with bear-like characters which is being found in the middle Tertiary faunas does, however, suggest the possibility of independent origin of certain of the groups which have been brought together in the Ursidae.

Occurrence: Virgin Valley Beds; locality 1065, Virgin Valley, Humboldt County, Nevada.

TEPHROCYON, near KELLOGGI, n. sp.

A single second lower molar of *Tephrocyon* (no. 12542, fig. 7) was found in the beds at Thousand Creek. This specimen very closely resembles M_2 of the type specimen of *T. kelloggi*, but is slightly shorter and is a little narrower posteriorly. It is hardly to be distinguished from *T. kelloggi* and may be referred to that species tentatively.

Occurrence: Thousand Creek Beds; locality 1103, Thousand Creek, Humboldt County, Nevada.

MEASUREMENTS, No. 12542

M_2, anteroposterior diameter...................................... 9.9 mm.
M_2, greatest transverse diameter................................. 5.7

TEPHROCYON(?), compare RURESTRIS (Condon)

In the collection from Little High Rock Cañon there is a fragment of a lower jaw (figs. 8a and 8b) with P_4 and M_1 which represents a canid. This specimen, no. 12503, differs in form and dimension of P_4 and M_1 from the type specimen of *T. rurestris*. P_4 is a rather heavy tooth with both posterior cusp and basal tubercle. As in *T. rurestris* there is no anterior basal tubercle. In M_1 the metaconid seems relatively smaller than in the typical species, but it is not easy to judge of this character with absolute certainty, as the two teeth are not available in the same stage of wear. The heel of M_1 is wide, while the hypoconid and entoconid are of nearly equal size.

M_1 of this form may differ from *T. rurestris* in acuteness of the protoconid and paraconid, and in smaller size of the metaconid.

Otherwise the resemblance is very close.   As no. 12503 has an absolutely unworn M_1, while in the type of *T. rurestris* this tooth is considerably worn, the difference may appear slightly exaggerated.
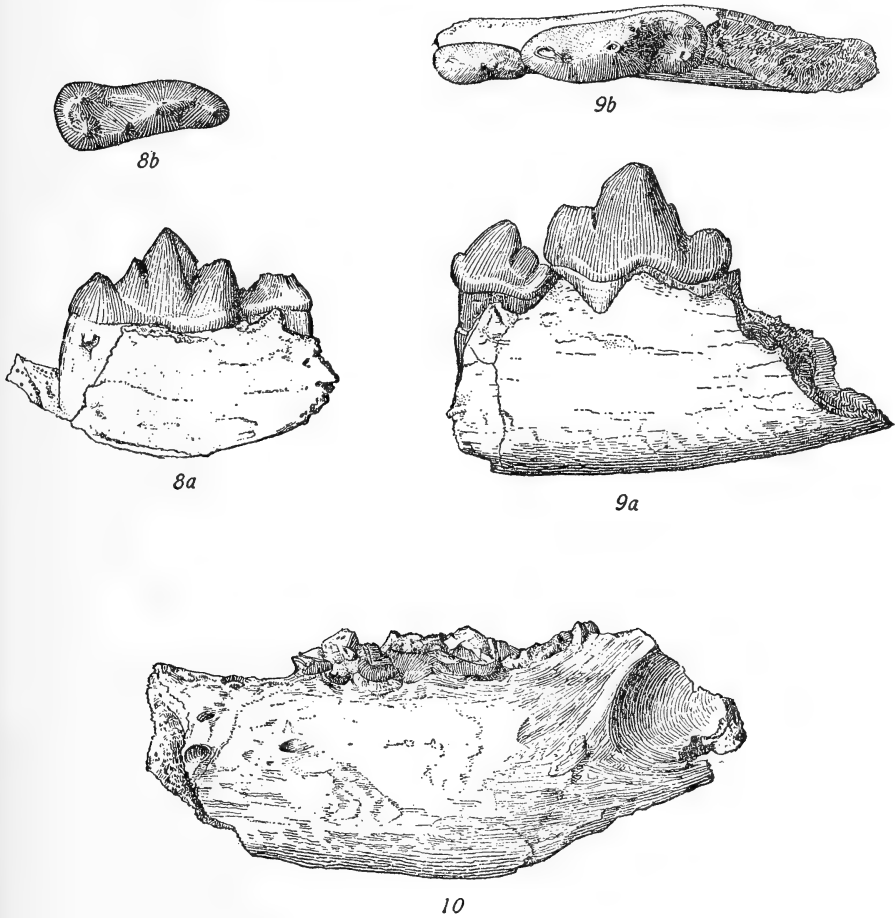
FIGS. 8a AND 8b.   *Tephrocyon*(?), compare *rurestris* (Condon).   No. 12503, natural size. Virgin Valley Beds, Little High Rock Cañon, Nevada.   Fig. 8a, M_1 and P_4, inner side; fig. 8b, M_1, superior view.

FIGS. 9a AND 9b.   *Tephrocyon*(?), sp. *a*. M_1 and P_4.   No. 12504, natural size.   Virgin Valley Beds, High Rock Cañon, Nevada.   Fig. 9a, outer side; fig. 9b, superior view.

FIG. 10.   *Aelurodon*(?), sp.   A portion of the lower jaw.   No. 12545, $\times \frac{2}{3}$.   Virgin Valley Beds, High Rock Cañon, Nevada.

It is desirable to have M_2 represented before attempting to establish the identity of the two forms with certainty.

Occurrence: Virgin Valley Formation; locality, Little High Rock Cañon, Humboldt County, Nevada.

<div align="center">MEASUREMENTS</div>

	Type of $T.$ rurestris	No. 12503
P_4, anteroposterior diameter	11.5 mm.	11.7
P_4, transverse diameter	6.	6.3
M_1, anteroposterior diameter	20.	22.3
M_1, anteroposterior diameter of heel	6.	6.4
M_1, transverse diameter of heel	....	8.4
Height of mandible below protocone of M_1	20.	....

<div align="center">TEPHROCYON(?), sp. a</div>

The jaw fragment no. 12504 from High Rock Cañon (figs. 9*a* and 9*b*) represents a form not differing greatly from the specimen tentatively referred to *T. rurestris*. The teeth on this specimen are somewhat larger than in the type of *T. rurestris*; P_4 is somewhat thinner and possesses an anterior basal tubercle; and the tubercles on the heel of M_1 are quite uneven in size, the entoconid being considerably smaller than the hypoconid.

There may be some doubt as to whether this specimen actually represents the genus *Tephrocyon*. In so far as it differs from *Tephrocyon* it approaches the dogs of the *Canis* type.

<div align="center">MEASUREMENTS</div>

P_4, anteroposterior diameter	12.7 mm.
P_4, transverse diameter	5.6
M_1, anteroposterior diameter	24.2
M_1, anteroposterior diameter of heel	6.4
M_1, transverse diameter of heel	8.4
Height of mandible below protocone of M_1	25.

<div align="center">AELURODON(?), sp.</div>

A fragment of a large jaw (no. 12545) from High Rock Cañon (fig. 10) represents a form certainly quite different from any of the species mentioned above. The jaw is very short and massive. The dental series includes three molars and at least three premolars, though the alveoli of the anterior premolars are not clearly shown. The inferior carnassial has about the same anteroposterior diameter as in specimen 12504 referred to tentatively as *Tephrocyon*(?), sp. *a*, but the relation of the dimensions of this tooth to those of the jaw is entirely different. This specimen evidently represents a type

generically different from the forms referred to *Tephrocyon*.   The short massive mandible suggests *Aelurodon*, though the teeth seem to be relatively small and weak for any of the species thus far described in that genus.

Occurrence: Virgin Valley Formation, High Rock Cañon, Humboldt County, Nevada.

<div align="center">MEASUREMENTS</div>

Height of mandible below protoconid of M_1............................ 39. mm.
Thickness of mandible below protoconid of M_1........................ 12.
M_1, approximate anteroposterior diameter........................... 25.

<div align="center">CANIS(?) DAVISI, n. sp.</div>

Type specimen, no. 545, Univ. Calif. Col. Vert. Palae. Mascall (?) Beds near Rattlesnake Creek, John Day Valley, Oregon, figured and described without specific designation by J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 5 and 6, fig. 1.
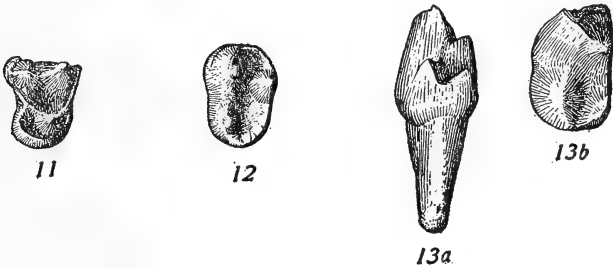
FIG. 11.   *Canis(?) davisi*, n. sp. M^1.   No. 12505, natural size.   Thousand Creek Beds Thousand Creek, Nevada.

FIG. 12.   *Canis(?)*, sp.; near *davisi*. M_2, seen from above.   No. 12543, $\times$ 1½.   Thousand Creek Beds, Thousand Creek, Nevada.

FIGS. 13*a* AND 13*b*.   *Canis(?)*, sp.; near *davisi*. M_1.   No. 12543, $\times$ 1½.   Thousand Creek Beds, Thousand Creek, Nevada.   Fig. 13*a*, posterior view; fig. 13*b*, posterior region of the tooth seen from above.

A single first upper molar from Thousand Creek (fig. 11) shows the same characters as M^1 in the specimen described some years ago from near Rattlesnake Creek, Oregon, and may be referred to that species.

In the type specimen the molars are a little smaller than in the living coyotes of eastern Oregon and M^2 is relatively a little larger than in the Recent species.   The outer cusps of M^1 are laterally compressed to such an extent that the cusps are noticeably sharp.

The protocone together with the incipient protoconule and metaco-
nule form a wide and sharply-marked V-ridge. The high and
narrow hypocone swings forward to a point approximately even
with the apex of the protocone.

The molar tooth from Thousand Creek is almost identical with
the type specimen in form. The hypocone of M^1, which was some-
what worn in the type, is here complete, and shows this tooth to be a
little wider transversely than in the original figure of the type
specimen.

Occurrence: Mascall or Rattlesnake Beds, eastern Oregon;
locality 1101, Thousand Creek Beds, Thousand Creek, Humboldt
County, Nevada.

MEASUREMENTS

	No. 545	No. 12505
M^1, anteroposterior diameter	9.7 mm.	9.9
M^1, anteroposterior diameter at narrowest point between protocone and paracone	7.3	7.6
M^1, transverse diameter	13.3	a12.5

a approximate, outer edge broken.

CANIS(?), sp.; near DAVISI, n. sp.

A complete second lower molar (fig. 12) and the posterior portion
of a lower carnassial (figs. 13a and 13b) from Thousand Creek
represent a small canid species apparently not far removed from the
existing *Canis*.

The trigonid portion of M_2 consists of a small but nearly centrally
located protoconid and a considerably reduced metaconid. The
heel consists of a small hypoconid with a basin-like expansion of
the entoconid region. The form of this tooth is near that of M_2 in
some of the existing forms of *Canis*, and there seems reason for
considering that this specimen represents a form near that genus.

On the fragment representing the lower carnassial, the metaconid
is of moderate size. On the heel the hypoconid is considerably
larger than the entoconid, and is distinctly compressed laterally,
as is the entoconid also. This tooth was probably, but not certainly,
associated with the second lower molar described above.

This form is quite distinct from the species of *Tephrocyon* in the
structure of M_2, and in the form of the heel of M_1. The heel of the
inferior carnassial is narrower than in *Tephrocyon*, the tubercles are
distinctly compressed laterally, and the entoconid is relatively

small. M_1 differs also from the forms referred to *Tephrocyon(?)*, sp. *a*, and *T.* cf. *rurestris* in the narrowness of the heel, and in the compression of its tubercles.

It seems to the writer not improbable that the inferior molars in no. 12543 are from an animal of the same species as the upper molar referred to as *Canis davisi;* at any rate they represent a closely similar canid type.

Occurrence: Thousand Creek Beds; locality 1100, Thousand Creek, Humboldt County, Nevada.

MEASUREMENTS

	No. 12543
M_1, anteroposterior diameter of heel	5.5 mm.
M_1, transverse diameter of heel	6.4
M_2, anteroposterior diameter	8.5
M_2, transverse diameter	6.

CANID, FORMS INDETERMINATE

A number of scattered limb bones from Virgin Valley and Thousand Creek represent several canid forms, and possibly belonging to some of the species described above.

Several small astragali (fig. 15) obtained at different localities are apparently to be referred to the same form, which is possibly a species of *Tephrocyon.* They are characterized by a sharply-defined shelf at the anterior end of the trochlea and by the rather marked lateral twist of the neck.

An astragalus representing another type of canid is shown in figure 16.

INDETERMINATE HUMERI

The distal end of a carnivore humerus from Virgin Valley (no. 10650) and one from Thousand Creek (no. 12553) represent two distinct generic types. Both may be feline or they may both represent a primitive dog-like form.

In specimen 10650 (fig. 14) the broad distal region of the humerus shows a strongly developed inner condyle and supinator ridge, and a large supracondyloid foramen is present. The supinator ridge extends upward as a sharp ridge to the narrowest portion of the shaft, where the bone is broken off.

In specimen no. 12553 the distal end is no wider than in no. 10650, and the shaft is much smaller, but the anteroposterior diameter of
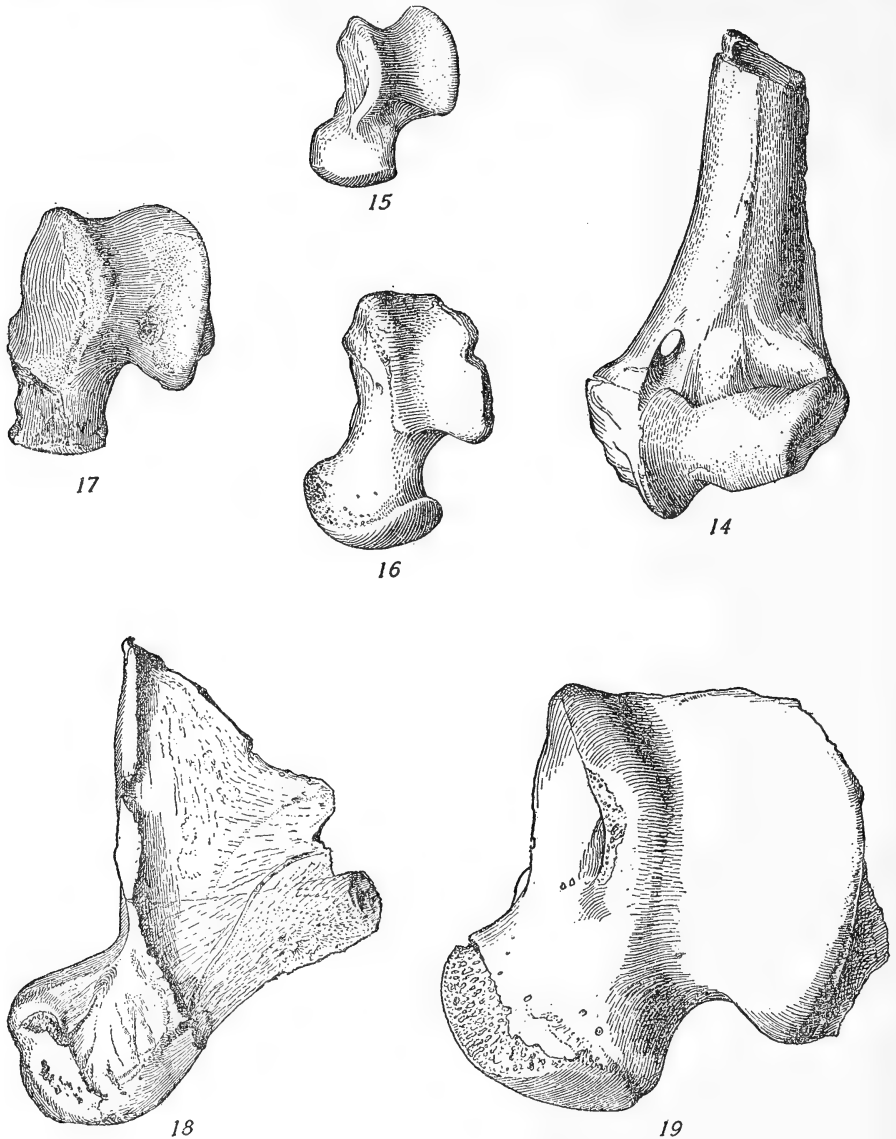
FIG. 14.   Distal end of humerus.   Genus indet.   No. 10650, natural size.   Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 15.   Astragalus of small canid.   *Tephrocyon*(?).   No. 12547, natural size.   Thouand Creek Beds ?, Thousand Creek, Nevada.

FIG. 16.   Astragalus of canid.   No. 19410, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.

FIG. 17.   *Felis*, sp. *b*.   Astragalus.   No. 12546, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.

FIG. 18.   *Felis*, sp. *a*.   Terminal phalange.   No. 12551, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.

FIG. 19.   *Felis*, sp. *a*.   Astragalus.   No. 19411, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.

the trochlea is much greater.   The olecranon fossa is also much larger than in no. 10650.

MEASUREMENTS OF HUMERUS

	No. 10650	No. 12553
Greatest width of distal end..................................	35.8 mm.	....
Width from bottom of trochlear groove to extreme outer side......	18.4	18.4
Least anteroposterior diameter of trochlea.....................	8.2	11.6
Width measured from middle of lower end of supracondyloid foramen to outer condyle................................	27.	27.
Anteroposterior diameter of shaft forty-five millimeters above the distal end...	12.4	10.

PROCYONIDAE

PROBASSARISCUS ANTIQUUS MATTHEWI, new genus and new variety

Type specimen no. 12539, Univ. Calif. Col. Vert. Palae.   From the Virgin Valley Beds; locality 1095, Virgin Valley, Humboldt County, Nevada.

Probassariscus, new genus.   Characterized by the presence of a well-developed paraconid ridge on M_2, and by the greater width of the heel and better development of the entoconid region of M_2 than in *Bassariscus*.

In the collections from Virgin Valley there is a single lower jaw fragment, with the posterior four teeth (figs. 21a and 21b), which represents a form closely related to the form described as *Bassariscus antiquus* from the Snake Creek Beds of western Nebraska.[10]   The differences in dimensions which appear are not considered for the present as indicating more than a varietal separation from the Snake Creek species.   The Virgin Valley form is named in honor of Dr. W. D. Matthew.

The jaw fragment represents an animal of approximately the same size as the Recent *B. astuta*.   The mandible is slightly higher than that of the Recent specimens used for comparison, but is not thicker.   A large mental foramen is present below the middle of P_3.   A much smaller foramen is present in *B. astuta* under the anterior root of this tooth.

In the inferior dental series of the specimen from Virgin Valley, M_1 is absolutely smaller and M_2 absolutely larger than in the living species, and M_2 is relatively considerably larger than in either the Recent species or the form from the Snake Creek Beds.

P_3 is represented only by alveoli of the two roots. P_4 is slightly larger than in the modern *B. astuta*.   The crown is not satisfac-

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[10] Matthew, W. D., & Cook, H. J., Bull. Am. Mus. Nat. Hist., vol. 26, p. 377, 1909.

torily shown, but the posterior cusp seems to have been wider than in the living species.

M_1 is unfortunately considerably worn, but is evidently closely similar in form to the corresponding tooth of the living species.
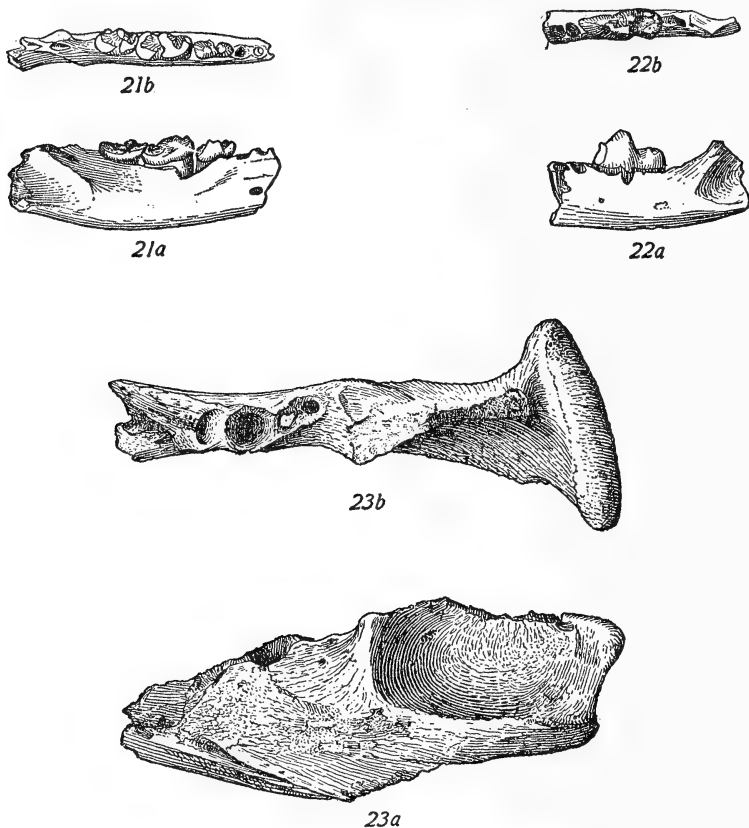
FIGS. 21a and 21b. *Probassariscus antiquus matthewi*, n. gen. and n. var. Mandible with dentition. Type specimen, no. 12539, natural size. Virgin Valley Beds. Virgin Valley, Nevada. Fig. 21a, outer side; fig. 21b, superior view.

FIGS. 22a and 22b. *Mustela furlongi*, n. sp. Fragment of mandible with M_1. Type specimen, no. 12540, × 2. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 22a, outer side; fig. 22b, superior view.

FIGS. 23a AND 23b. Mustelid, indet. Fragment of lower jaw. No. 12555, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 23a, outer side; fig. 23b, superior side.

The paraconid is possibly slightly thicker transversely, or is turned so that its blade is more nearly transverse to the anteroposterior axis of the tooth.

M_2 differs from the corresponding tooth of *B. astuta* in its relatively larger size, and in the presence of a distinct paraconid ridge. Owing to the worn condition of this tooth it is not possible to determine exactly the stage of development of the paraconid.   A paraconid is also shown in the illustration of the type specimen of *P. antiquus* from Snake Creek.   The talonid region differs from that of *B. astuta* in its greater width.   The form and position of the tubercles are much the same as in the Recent species, excepting that the region of the entoconid is more elevated and is separated from the metaconid by a sharp fissure.

The Virgin Valley specimen is certainly closely related to that described by Matthew and Cook from the Snake Creek Beds.   In both forms the paraconid is present on M_2, whereas it is absent entirely in the living species. M_2 is also relatively large compared with the inferior carnassial in both.

Occurrence: Virgin Valley Beds; locality 1095, Virgin Valley, Humboldt County, Nevada.

<div align="center">

MEASUREMENTS

</div>

	P. antiquus matthewi	*P. antiquus*	*B. astuta*
Length, P_4 to M_2 inclusive....................	17.6 mm.	17.4	17.3
Depth of jaw below M_1......................	7.8	7.	6.8
P_4, anteroposterior diameter...................	5.2	....	5.
M_1, anteroposterior diameter..................	6.8	7.9	7.5
M_1, greatest transverse diameter..............	3.8	3.8	3.7
M_2, anteroposterior diameter.................	5.5	5.9	5.2
M_2, greatest transverse diameter..............	3.5	3.5	3.2

<div align="center">

URSIDAE(?)

URSUS(?), sp.

</div>

A large terminal phalange, no. 12554 (fig. 20), from the Thousand Creek Beds at locality 1100 at Thousand Creek, closely resembles the terminal phalanges of the bears, but may represent a very large canid form.

<div align="center">

MUSTELIDAE

MUSTELA FURLONGI, n. sp.

</div>

Type specimen, a lower jaw fragment with complete carnassial tooth, no. 12540, Univ. Calif. Col. Vert. Palae.   From Thousand Creek Beds; locality 1103, Thousand Creek, Humboldt County, Nevada.

In the collections from near Thousand Creek there are two fragments of lower jaws with carnassials which represent an exceedingly small musteline species. The mandible of the smaller specimen measures only about three and one-half millimeters in height below the carnassial. The jaws are also apparently rather slender, and the anterior end of the masseteric fossa does not extend as far forward as in most of the modern forms. (See figs. 22a and 22b.)

M_1 possesses a well developed metaconid and a long basin-like heel. The metaconid is relatively a little larger than in the modern species of *Mustela*. The long, wide heel is bordered by a prominent horseshoe-shaped marginal wall. M_2 is not present, but the tooth must have been much reduced, as the alveolus for the single root is small. P_4, as shown in specimen 12540, is two-rooted.

This species is somewhat more primitive than the Recent *Mustela* in the form of the trigonid of M_1, while the inner wall of the heel of
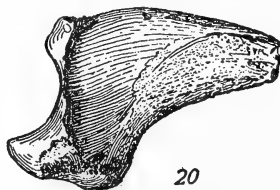
FIG. 20. *Ursus*(?), sp. Terminal phalange. No. 12554, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

this tooth is somewhat higher. More complete material may show that this form is generically distinct from the species grouped under the typical *Mustela*. In view of its evident close relationship to these forms it may be classed with them until more material is obtained.

Occurrence: Thousand Creek Beds; locality 1103, Thousand Creek, Humboldt County, Nevada.

MEASUREMENTS

	No. 12541	No. 12540
Height of mandible below protoconid of M_1	4.3 mm.	3.4
M_1, anteroposterior diameter	5.8	5.1
M_1, transverse diameter	2.5	2.
M_1, anteroposterior diameter of heel	2.1	1.6
M_2, anteroposterior diameter of alveolus	1.5	1.4

MUSTELID(?), indet.

The posterior half of a lower jaw (no. 12555, figs. 23a and 23b) lacking the teeth and the coronoid process possibly represents a

large mustelid form.   The inferior margin of the mandible is more strongly convex below the anterior region of the masseteric fossa than in most of the existing mustelids, but approximates the form in *Potamotherium lacota* in this respect.   The angle is broad and much flattened inferiorly, and approaches the condyle very closely.   The masseteric fossa is short and deep.   The dental foramen is situated only a short distance below a line connecting the posterior margin of the alveolus of the last molar and the inferior border of the condyle.

The alveoli of two molars are present.   The posterior tooth was two-rooted and situated slightly transverse to the anteroposterior axis of the jaw.   The posterior portion of this tooth rested partly on a distinct inwardly projecting prominence of the alveolar margin which extends well behind the anterior border of the coronoid process.   On the second tooth from the posterior end of the inferior series the posterior root was circular in cross-section and considerably flared above.   The anterior root is narrowed anteroposteriorly, and stands transverse to the long axis of the jaw.   The form of the anterior root of this tooth is not that below the ordinary cutting blade on the trigonid region of M_1 in most carnivores.   Either this alveolus represents the anterior root of a M_2, in which case M_3 would also be two-rooted, or the carnassial was short and the trigonid portion of a distinctly crushing type.   As the jaw was evidently short and massive it is improbable that a two-rooted M_3 was present; in other words the carnassial was presumably of a crushing type.

With the information available it is not advisable to attempt a definite correlation of this form with any known type.   It is perhaps significant that Matthew and Cook describe, from the Snake Creek Pliocene, a mustelid which differs from *Potamotherium* in the presence of a two-rooted M_2.

Occurrence: Thousand Creek Beds; locality 1103, Thousand Creek, Humboldt County, Nevada.

FELIDAE

FELIS, sp. *a*.

Numerous isolated limb bones including astragali, a calcaneum, phalanges, metatarsals, and portions of the radius and ulna represent a large feline form exceeding average specimens of the Recent

African lion in size. (See figs. 18 and 19.) These specimens are comparable to the fragmentary material described from the Snake Creek Beds by Matthew and Cook, or to the large cats described as *Felis maxima* by Scott and Osborn[11], from the Loup Fork of Kansas.

Judging from the number of loose fragments found, this species, or group of species, was not uncommon in the Virgin Valley and Thousand Creek faunas and seems to have been an important element in the West-American Carnivora at this time.

Whether the species represented by the material at hand was machaerodont or typically feline is not definitely determined.

Occurrence: Virgin Valley Beds; locality 1064, Virgin Valley, Nevada; Thousand Creek Beds; locality 1063, 1096, 1097, 1099, 1100, 1101, Thousand Creek, Humboldt County, Nevada.

MEASUREMENTS

Ulna, no. 12552.
    Least anteroposterior diameter behind sigmoid cavity.............. 38.4 mm.
    Anteroposterior diameter measured across the coronoid process...... 63.5
Astragalus, no. 11891.
    Greatest anteroposterior diameter................................ 63.5
    Greatest width across the trochlea............................... 43.
    Length of neck.. 24.5
Astragalus, no. 12548.
    Greatest anteroposterior diameter................................ 60.5
    Greatest width across the trochlea............................... 42.
    Length of neck.. 21.5
Metatarsal II, no. 12549.
    Anteroposterior diameter of proximal end......................... 35.8
    Transverse diameter of middle of shaft........................... 16.
Metatarsal III, no. 12550.
    Anteroposterior diameter of proximal end......................... 40.
    Transverse diameter of shaft immediately below lateral articular
       faces of proximal end.. 20.8
Phalange III, no. 12551.
    Height of phalange from lower side of basal process to summit of
       core (exclusive of hood)...................................... 63.7
    Greatest transverse diameter of middle region of phalange.......... 24.2

FELIS, sp. *b*

A broken astragalus and a middle phalange, no. 12546, from the Thousand Creek region represent a feline species about as large as the existing cougar (see fig. 17).

[11] Scott, W. B., and Osborn, H. F., Bull. Mus. Comp. Zool., vol. 20, p. 70, 1890.

Measurements of Astragalus, No. 12546

Greatest anteroposterior diameter.................................... 32.8 mm.
Greatest width across the trochlea............................... 19.

Occurrence: Thousand Creek Beds; locality 1104, Thousand Creek, Humboldt County, Nevada.

RODENTIA

The numerous rodent forms in the fauna of Virgin Valley and Thousand Creek have already been described by Miss Louise Kellogg[12] and by Mr. E. L. Furlong.[13]   Fifteen species are listed by Miss Kellogg, of which five occur at Virgin Valley and thirteen at Thousand Creek.   Three species, *Aplodontia alexandrae*, *Mylagaulus monodon*, and *Lepus vetus* are common to the two faunas.

The species are distributed as follows:

Virgin Valley	Thousand Creek
Aplodontia alexandrae Furlong.	*Arctomys nevadensis* Kellogg.
Mylagaulus monodon Cope.	*Arctomys minor* Kellogg.
Mylagaulus pristinus Douglass	*Citellus*, sp.
Palaeolagus nevadensis Kellogg.	*Aplodontia alexandrae* Furlong.
Lepus vetus Kellogg.	*Mylagaulus monodon* Cope.
	Eucastor lecontei (Merriam, J. C.)?
	Dipoides, sp.
	Entoptychus minimus Kellogg.
	Peromyscus antiquus Kellogg.
	Peromyscus(?), sp.
	Diprionomys parvus Kellogg.
	Diprionomys magnus Kellogg.
	Lepus vetus Kellogg.

SCIURIDAE

ARCTOMYS NEVADENSIS Kellogg

Arctomys nevadensis Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 422, figs. 1a to 2, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

[12] Rodent Fauna of the Late Tertiary Beds at Virgin Valley and Thousand Creek, Nevada, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 421–437, 1910.
[13] An Aplodont Rodent from the Tertiary of Nevada, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 397–403, 1910.

ARCTOMYS MINOR Kellogg

Arctomys minor Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 425, figs. 3 to 7, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

CITELLUS, sp.

Citellus, sp., Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 427, fig. 8, 1910.

A fragmentary specimen comprising a part of the lower jaw with M_1 apparently represents this genus.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

APLODONTIDAE

APLODONTIA ALEXANDRAE Furlong

Aplodontia alexandrae Furlong, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 397–403, figs. 1 to 5c, 1910.

Occurrence: Rare in Virgin Valley Beds, Virgin Valley, Nevada; numerous specimens found in the Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

MYLAGAULIDAE

MYLAGAULUS MONODON Cope

Mylagaulus monodon, Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 427, figs. 9a to 10b, 1910.

Occurrence: Virgin Valley Beds, Virgin Valley, Nevada; Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

MYLAGAULUS PRISTINUS Douglass

Mylagaulus pristinus, Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 429, figs. 11a to 12b, 1910.

Occurrence: Virgin Valley Beds, Virgin Valley, Humboldt County, Nevada.

CASTORIDAE

EUCASTOR LECONTEI (Merriam, J. C.)

Eucastor lecontei (Merriam), Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 430, fig. 13, 1910.

Occurrence: Thousand Creek Beds ?, at Thousand Creek, Humboldt County, Nevada.

DIPOIDES, sp.

Dipoides, sp., Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 431, fig. 14, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

GEOMYIDAE

ENTOPTYCHUS MINIMUS Kellogg

Entoptychus minimus Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 431, fig. 15, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

CRICETIDAE

PEROMYSCUS ANTIQUUS Kellogg

Peromyscus antiquus Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 433, fig. 16, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

PEROMYSCUS(?), sp.

Peromyscus(?), sp., Kellogg, Miss Louise, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 433, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

HETEROMYIDAE

DIPRIONOMYS PARVUS Kellogg

Diprionomys parvus Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 433, figs. 17*a* and 17*b*, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

DIPRIONOMYS MAGNUS Kellogg

Diprionomys magnus Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 434, fig. 18, 1910.

Occurrence: Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

LEPORIDAE

PALAEOLAGUS NEVADENSIS Kellogg

Palaeolagus nevadensis Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 435, figs. 19*a* and 19*b*, 1910.

Occurrence: Virgin Valley Beds, Virgin Valley, Humboldt County, Nevada.

LEPUS VETUS Kellogg

Lepus vetus Kellogg, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 436, fig. 20, 1910.

Occurrence: Virgin Valley Beds, Virgin Valley, Nevada; Thousand Creek Beds, Thousand Creek, Humboldt County, Nevada.

UNGULATA

EQUIDAE

Remains of horses are among the most common fossils at both Virgin Valley and Thousand Creek. In the small collection of fragmentary material obtained by Mr. Smith and the writer in 1906 Mr. Gidley[14] found at least five species represented. The material obtained during the past season unfortunately consists only of scattered teeth and limb bones. It is, however, sufficient to add considerably to what has been known regarding this group.

The forms present represent the genera *Hypohippus*, *Parahippus*, *Merychippus*, *Pliohippus*(?), and possibly *Equus*.

An examination of the collection according to localities shows that *Hypohippus*, *Parahippus* and *Merychippus* are found only in the Virgin Valley Beds, and do not appear at all in the deposits at Thousand Creek, while *Pliohippus*(?) and *Equus* are found at Thousand Creek and not in Virgin Valley.

HYPOHIPPUS, near OSBORNI Gidley

There is a considerable number of specimens of teeth and limb-bones which are to be referred to this genus. The specific characters, so far as determinable, represent a form combining to some extent the characters of *Hypohippus equinus* of the Deep River Beds of

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[14] Gidley, J. W., Notes on a Small Collection of Fossil Mammals from Virgin Valley, Nevada, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, pp. 235–246, 1908.

Montana and *H. osborni* from the Pawnee Creek Beds of Colorado. Until both the typical Great Plains species and the Virgin Valley forms are better known a final judgment on the specific determination of the Nevada species may best be postponed.

A lower jaw, no. 10655, with the milk molars and a portion of the first permanent molar in the process of eruption was referred tentatively to *H. equinus* (Scott) by Gidley.[15] As this specimen was represented principally by the lower milk dentition which had not been known before, an exact comparison with the known species was very difficult. As shown by Gidley the lower milk molars of *Hypohippus*, as represented by this form, are distinguished from those of *Mesohippus* by the heavier and better developed external basal cingula, the protoconid and hypoconid being fuller and wider transversely, and the teeth more specialized in general. Especially is the advanced development noticeable in lower milk molar two in *Hypohippus* "in which the anterior external cusp has attained a completely crescentic form similar to that of the posterior cusp, while in *Mesohippus* this tooth has but one crescent, or V, the posterior one."

M_1, the only permanent tooth represented in specimen 10665, described by Gidley, is slightly larger than the teeth of *H. equinus* and is a little smaller than in *H. affinis*. It is of almost exactly the same size, according to the figure, as that of an unnamed species of *Hypohippus* described by Gidley[16] from the Loup Fork of South Dakota.

The permanent inferior cheek-tooth dentition of a species of *Hypohippus* apparently identical with the form described by Gidley is exhibited in several specimens. A lower jaw (no. 12587, figs. 28*a* and 28*b*) shows all of the lower molars and premolars perfectly preserved excepting a small portion of M_3 and P_1. A series of three perfectly preserved teeth (no. 11760, figs. 26 and 27), found together, represent molars one to three of another individual.

In general the teeth of specimen 12587 resemble the inferior series of *H. equinus* as figured and described by Scott. They differ in their relatively greater width and in the smaller size of P_1. The posterior region of the median internal, or metaconid, pillars is not distinctly angular as in *H. equinus* as figured by Scott. This

[15] *Op. cit.*, p. 236.
[16] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 22, p. 136, 1906.

difference may be due in part to wear. On P_3, P_4, and M_1 a very small tubercle appears on the inner side between the metaconid and entoconid. In M_1 and M_2 there is no suggestion of a groove separating a metastylid from the metaconid. There is in fact no distinct
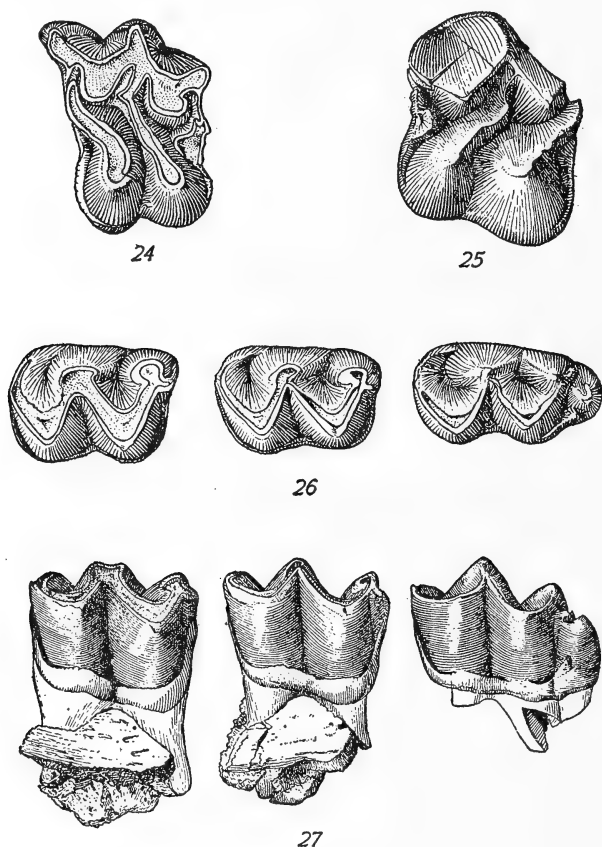

24

25

26

27

FIG. 24. *Hypohippus*, sp. Upper molar. No. 12564, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 25. *Hypohippus*, near *osborni* Gidley. Upper molar. No. 11570, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 26. *Hypohippus*, near *osborni* Gidley. M_1 to M_3, occlusal view. No. 11760, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 27. Same as fig. 26, outer side, natural size.

metastylid present. The external cingulum is quite strongly developed.

The three molars comprising no. 11760 show apparently the same dimensions as no. 12587. The posterior region of the metaconid is

distinctly angular as in *H. equinus*, the hypostylid is a little more prominent than in no. 12587 and the small tubercle is not present between the inner borders of the metaconid and entoconid. Though distinguished by the slight difference just mentioned it is hardly probable that these two forms are specifically separable.

A well preserved upper molar one or two (no. 11570, fig. 25) represents a form of *Hypohippus* in which the teeth appear to be relatively somewhat narrower anteroposteriorly than in *H. equinus*, and in this respect approach the type of *H. osborni*.
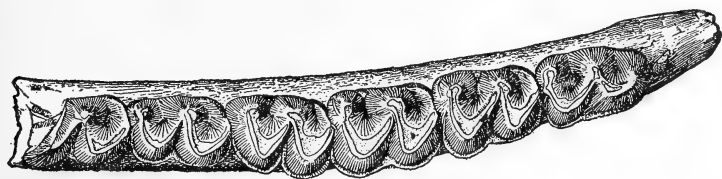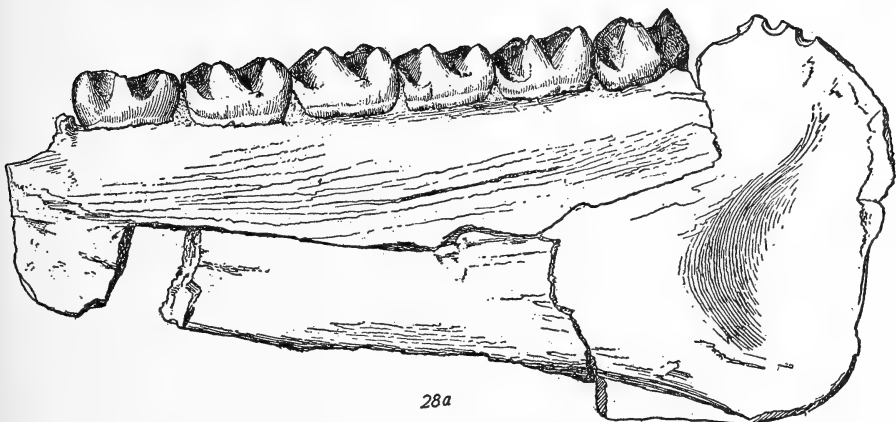
Figs. 28a and 28b. *Hypohippus*, near *osborni* Gidley. Lower jaw with dentition. No. 12587, × ⅝. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 28a, outer side; fig. 28b, superior view.

An upper molar specimen (no. 12564, fig. 24) is apparently identical in size with M_3 of *H. osborni*. The abruptness of the walls surrounding the impressed areas on the outer side of the paracone and metacone is so different from the much more gently curving lines of the outer side of tooth no. 11570 as to suggest that the two teeth represent different species; they may, however, belong to the same form.

From such evidence as is available it seems probable that none of the specimens of *Hypohippus* from the Virgin Valley region are identical with *H. equinus* though, as suggested by Gidley, the difference is very slight. The upper molar represented in no. 12564 is apparently near to *H. osborni*, but not actually identical with it. The lower molars of series no. 11760 differ quite distinctly from *H. equinus* in width and in the smaller size of P_1. According to the measurements which Dr. W. D. Matthew has kindly furnished, the lower molars of *H. osborni* show relatively greater width than in *H. equinus*, as in the upper molars. The lower molars of the Virgin Valley forms are somewhat larger but especially wider than those of *H. equinus*. They are somewhat smaller than the corresponding teeth of the type specimen of *H. osborni*, but approach this form a little more closely than to *H. equinus*.

MEASUREMENTS

	H. osborni*	H. equinus	H. affinis	No.12587	No. 11570	No. 12564
P^3, anteroposterior diameter	25.7 mm.	25				
P^3, transverse diameter	28.7	27				
P^4, anteroposterior diameter	27.	25				
P^4, transverse diameter	29.9	26				
M^1, anteroposterior diameter	27.2	25				
M^1, transverse diameter	31.	28				
M^2, anteroposterior diameter	23.3	25			23.1	
M^2, transverse diameter	31.5	27			28.6	
M^3, anteroposterior diameter	21.	21				21.
M^3, transverse diameter	27.8	22				27.2

	H. osborni*	H. equinus	H. affinis	No.12587	No. 11760	No. 10665
Length of inferior premolar series	76.5	78		72.		
P_1, anteroposterior diameter	8.5	13		7.4?		
P_1, transverse diameter	6.2	6				
P_2, anteroposterior diameter	24.2	21		22.8		
P_2, transverse diameter	14.5	9		14.5		
P_3, anteroposterior diameter	23.9	22	28.	22.7		
P_3, transverse diameter	17.4	13	20.	17.7		
P_4, anteroposterior diameter	24.	22	27.5	23.		
P_4, transverse diameter	19.4	14	21.	18.6		
M_1, anteroposterior diameter	23.8	23	28.5	22.	22.2	
M_1, transverse diameter	18.1	14	20.	16.	16.5	15.8
M_2, anteroposterior diameter	23.5	22		21.	21.8	
M_2, transverse diameter	16.2	12		14.4	15.4	
M_3, anteroposterior diameter	26.3	25			25.	
M_3, transverse diameter	15.	10		13.	13.2	

* The dimensions of the inferior dentition were kindly furnished by Dr. W. D. Matthew.

PARAHIPPUS, compare AVUS (Marsh)

Several lower cheek teeth from Virgin Valley (figs. 29a to 29c) represent a species of *Parahippus* larger than *Parahippus crenidens* of the Deep River Beds or *P. brevidens* of the Mascall, but corresponding approximately in size to *P. nebrascensis* described by Peterson[17] from the upper Harrison Beds. This species should be compared with the doubtful *Parahippus avus* (Marsh) from the Mascall.

The crowns of the lower cheek teeth are short and the enamel is quite rough. On all of the specimens there is evidence of a considerable covering of cement. On the outer side there is a distinct shelf developed on the cingulum, and a small basal tubercle is present between the protoconid and hypoconid. The metaconid and metastylid pillars are distinctly separated. The entoconid pillar

FIGS. 29a TO 29c. *Parahippus*, compare *avus* (Marsh). No. 19403, natural size. Fig. 29a, outer view; fig. 29b, occlusal view; fig. 29c, inner view. Virgin Valley Beds, Virgin Valley, Nevada.

is also large and the entostylid is well developed. The development of the metaconid, metastylid, and entoconid pillars tends to narrow the inner ends of the anterior and posterior valleys much more than in *Hypohippus*. A characteristic feature of all of these specimens is seen in a small but distinctly developed fold on the posterior side of the ridge of the hypoconid extending toward the metastylid.

This form is evidently the least common of the Virgin Valley horses, *Merychippus* having been the most abundant, and *Hypohippus* more common than *Parahippus*.

Occurrence: Virgin Valley Beds; localities 1090 and 1095; Virgin Valley, Humboldt County, Nevada.

MEASUREMENTS

Inferior cheek tooth, P_4?

Anteroposterior diameter of crown	20.5 mm.
Greatest transverse diameter of crown	16.7
Height of slightly worn crown, measured at metaconid	11.9

[17] Peterson, O. A., Ann. Carneg. Mus., vol. 4, p. 57, 1906.

MERYCHIPPUS, near ISONESUS (Cope)

Teeth of *Merychippus* are the most common remains of fossil horses in Virgin Valley, where they occur in association with those of *Hypohippus*. They are found also at High Rock Cañon, farther to the south, but have not been seen in the beds at Thousand Creek.

In the collections obtained at Virgin Valley in 1906 Gidley[18] has recognized four forms of *Merychippus* teeth. These included a form referred provisionally to *Merychippus isonesus* (Cope), a second species (Gidley, species indet. 1) considered as possibly representing a new form of *Merychippus* with *Protohippus* affinities, a third (Gidley, species indet. 2) which was compared with *Merychippus seversus* (Cope), and a fourth (Gidley, species indet. 3) represented by a comparatively higher and straighter crowned form than the others.

In the larger collections now available from Virgin Valley the several forms present do not appear to represent any types other than those referred to by Gidley. Unfortunately the material nearly all consists of scattered teeth, excepting a few fragments of lower jaws with teeth. As the lower teeth are not associated with the upper dentition it is not possible to determine with certainty their relation to the forms described by Gidley, which were all represented by upper teeth. Taking into consideration the variability of hypsodont molar teeth of horses, it does not seem advisable to attempt a definite characterization of the species of *Merychippus* from the Virgin Valley region until some of the several forms present in this fauna are represented by more complete material than is now available.

Teeth of the forms referred to *M. isonesus* (Cope) (figs. 30*a*, 30*b*, 34*a*, and 34*b*) are the most common remains of Equidae in the Virgin Valley Beds.

Occurrence: Virgin Valley Beds at Virgin Valley and High Rock Cañon, Humboldt County, Nevada.

MERYCHIPPUS, near SEVERSUS (Cope)

A small form of *Merychippus* approximating the type of *M. seversus* (Cope) appears rarely in the beds at Virgin Valley, and is represented by several specimens occurring at High Rock Cañon

[18] Gidley, J. W., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 238, 1908.

in association with a larger *Merychippus* and a species of *Hypohippus*.

Occurrence: Virgin Valley Beds at Virgin Valley and at High Rock Cañon, Humboldt County, Nevada.
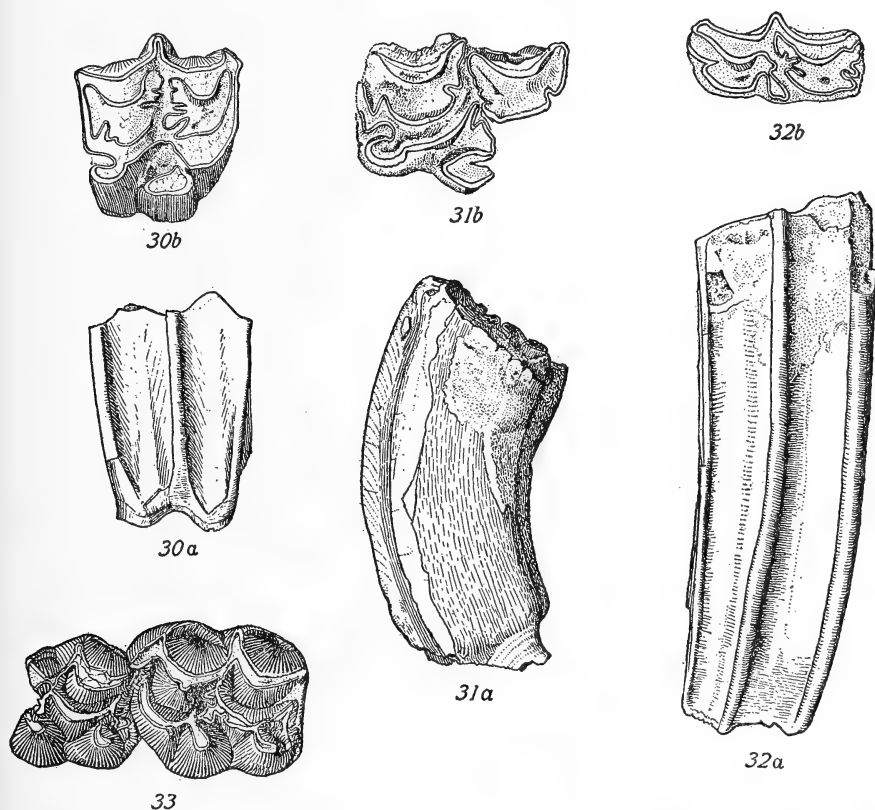
FIGS. 30a AND 30b. *Merychippus*, near *isonesus* (Cope). No. 11862, natural size. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 30a, occlusal view; fig. 30b, outer view.

FIGS. 31a AND 31b. *Pliohippus*(?), sp. Superior molar. No. 12582, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 31a, posterior side; fig. 31b, occlusal view.

FIGS. 32a AND 32b. *Equus*(?), sp.; or *Neohipparion*(?), sp. Superior molar. No. 12581, natural size. Thousand Creek Beds(?), Thousand Creek, Nevada. Fig. 32a, outer side; fig. 32b, occlusal view.

FIG. 33. *Merychippus*, sp. Superior milk molars. No. 19412, natural size. Soldier Meadows, Humboldt County, Nevada.

PLIOHIPPUS(?), SP.

At several localities in the Thousand Creek region remains were found representing an equine form much larger than the *Merychippus* species of Virgin Valley. The heavily cemented upper molars

are in most of the specimens (figs. 31*a* and 31*b*) a little shorter than in typical species of *Equus*, and show the strong curvature of *Pliohippus*. The wide enamel lakes show a moderate degree of plication. These teeth correspond in general with the type which is recognized by Gidley and by Matthew as *Pliohippus*. It would not however be entirely safe to refer them certainly to this group until more complete material is available. They may certainly be included within the limits of *Pliohippus* and *Protohippus* taken together.
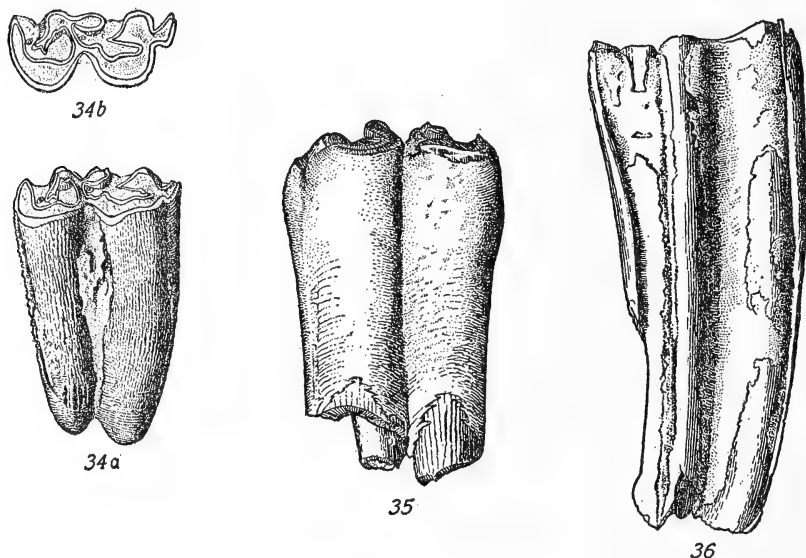
Figs. 34*a* AND 34*b*. *Merychippus*, near *isonesus* (Cope). Inferior cheek tooth. No. 11690, natural size. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 34*a*, outer side; fig. 34*b*, occlusal view.

Fig. 35. *Pliohippus*(?), sp. Inferior molar. No. 19413, outer side, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

Fig. 36. *Equus*(?), sp. Inferior molar. No. 19414, outer side, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

The pattern of the enamel presents peculiarities which may distinguish this form from other described species, but with the fragmentary material available it is not advisable to do more than characterize the type found here as apparently slightly different from the known species.

Remains of the *Pliohippus* type are the characteristic representatives of the Equidae in the Thousand Creek Beds.

EQUUS(?), sp.

At some of the localities at which teeth referred to *Pliohippus*(?) were collected a number of larger equine molars (figs. 32*a*, 32*b*, and 36) have been found in which the characters approach those of *Equus*. The crowns are longer and straighter and the fossets are relatively narrower transversely than in the specimens referred to *Pliohippus*. The character of the enamel folds on the posterior side of the prefossette and the anterior side of the postfossette is different from those in the forms referred to *Pliohippus*. In most of the characters in which these teeth differ from the specimens referred to *Pliohippus* they approach *Equus*. Relationship to *Neohipparion* can not be disproved, as the protocone region is not preserved in any of the specimens. The presence of a number of large, heavy astragali of the *Equus* type in the Thousand Creek region lends some support to the view that the large molar teeth represent that genus. It is also possible that these forms represent an *Equus* derived from a terrace formation of Pleistocene age which has possibly been laid down over the Thousand Creek Beds. In some of the localities at which these specimens were found there is distinct evidence of terracing, but no deposits have been recognized which are distinguishable from the Thousand Creek Beds into which the terraces are cut.

RHINOCEROTIDAE

Numerous scattered remains of rhinoceroses were found both at Virgin Valley and at Thousand Creek. The specimens consist mainly of loose foot-bones, with a few teeth and parts of jaws. None of the specimens seem to the writer to be definitely determinable.

APHELOPS(?), sp.

A last upper molar and a portion of a lower jaw with the dentition (figs. 37 and 38), and several astragali from Virgin Valley are tentatively referred to *Aphelops*.

TELEOCERAS(?), sp.

In the Thousand Creek Beds many scattered limb-bones of rhinoceroses were obtained, but no teeth appear in the collections

from these beds. From the limb elements, particularly the meta-podials and the astragali, it is evident that the common rhinoceroses of Thousand Creek are different from the common forms of Virgin Valley, and evidently represent a form near *Teleoceras*. It is not improbable that more than one form is represented at Thousand Creek.
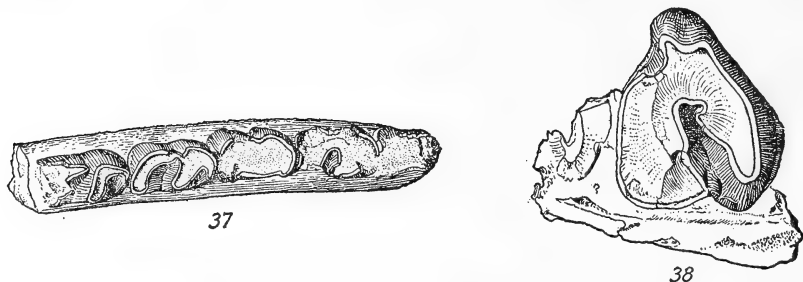
FIG. 37. *Aphelops*(?), sp. Fragment of inferior mandible with dentition. No. 11607, × ¼. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 38. *Aphelops*(?), sp. M³. No. 11672, × ½. Virgin Valley Beds, Virgin Valley, Nevada.
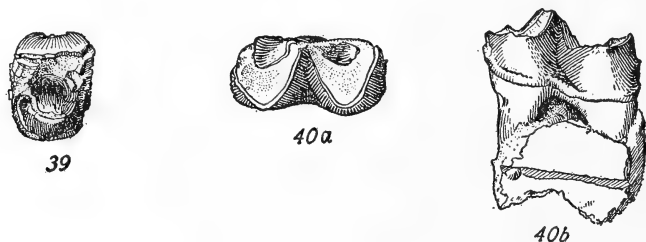
FIGS. 39 TO 40b. *Moropus*(?), sp.

FIG. 39. P⁴. No. 12596, × ½. Virgin Valley Beds, Virgin Valley, Nevada.

FIGS. 40a AND 40b. Inferior molar, M²?. No. 12595, × ½. Virgin Valley Beds, High Rock Cañon, Nevada. Fig. 40a, occlusal view; fig. 40b, lateral view.

CHALICOTHERIDAE

MOROPUS(?), SP.

Remains of chalicotheres have been obtained at the lower fossil-bearing horizon in Virgin Valley, and associated with a similar fauna at High Rock Cañon. Thus far no remains of representatives of this family have been seen in the collections from the upper fossiliferous horizons at Virgin Valley or from any of the localities in the Thousand Creek region.

The specimens obtained include a few teeth and a considerable

number of foot-bones, which closely resemble the forms referred to *Moropus* Marsh.

The teeth present include a representation of both the upper and lower cheek-tooth series.   A lower molar, no. 12595 (figs. 40*a* and 40*b*) is complete excepting for the loss of the most anterior portion of the parastylid ridge.   Although considerably worn the form of this tooth suggests that of M_2 in *Macrotherium grande*.   On the outer side of the tooth there is a well-marked shelf connecting the trigonid and talonid portions.   On the outer side of the protoconid a slight ridge is developed on the cingulum.   On the corresponding region of the hypoconid the surface is smooth.   Behind the hypoconid region there is a prominent shelf which slopes upward toward the distal end of the entoconid region.

MEASUREMENTS OF LOWER MOLAR, M_2?, No. 12595

Greatest anteroposterior diameter.................................. 40.2 mm.
Greatest transverse diameter...................................... 19.4
Anterior posterior diameter of heel............................... 22.3

In an upper cheek tooth, no. 12596 (fig. 39), evidently representing P^4, the ectoloph is comparatively simple as in *Moropus elatus*. The deuterocone is transversely compressed, while the anterior and posterior ends of this cusp are connected with the outer ridge. A deep pit or valley is formed between the outer and inner ridges as in *Moropus elatus*, but the inner cusp seems a little less like a simple crescent than in the corresponding tooth of that species as figured by Peterson.[19]

MEASUREMENTS OF P^4, No. 12596

Greatest transverse diameter...................................... 26.3 mm.
Greatest anteroposterior diameter................................. 20.2

Of the limb elements twelve phalangeal bones have been found in Virgin Valley and at Little High Rock Cañon.   They evidently represent both the fore and hind limbs.   Two or three specimens are apparently proximal phalanges not united with the second phalange. One specimen, no. 19406 (fig. 43), shows the union of the first and second phalanges.   This bone is relatively large and is much more compressed laterally than the other specimens.   It corresponds in form and size with the largest terminal phalange present, and both

[19] Peterson, O. A., Amer. Natur., vol. 41, p. 741, fig. 25, 1907.
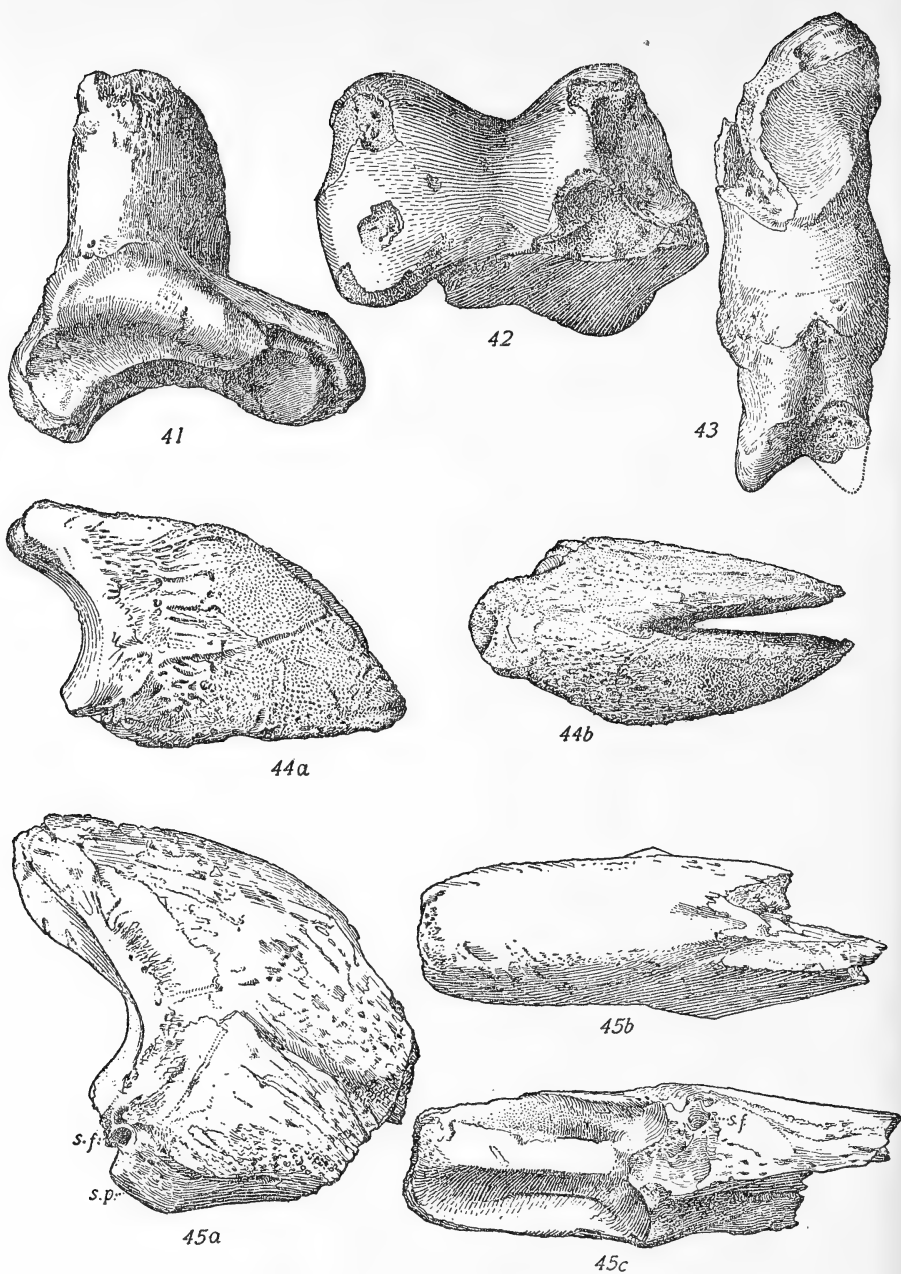
FIGS. 41 TO 45c. *Moropus*(?), various species. × ½. Virgin Valley Beds. Fig. 41,
High Rock Cañon. Figs. 42 to 44, Virgin Valley. Figs. 45a to 45c, Little High Rock Cañon.

FIG. 41. Calcaneum, superior view. No. 19405. Posterior end incomplete.

FIG. 42. Astragalus, superior view. No. 19404.

FIG. 43. Fused phalanges 1 and 2, superior view. No. 19406.

FIGS. 44a AND 44b. Terminal phalange. No. 10723. Fig. 44a, lateral view; fig. 44b,
superior view.

FIGS. 45a, 45b, AND 45c. Terminal phalange. No. 19407. Fig. 45a, lateral view; fig.
45b, superior view; fig. 45c, inferior view; *s.f.*, subungual foramen; *s.p.*, subungual process.

probably belong to digit two of the anterior limb. No specimens representing phalange two were found that were not co-ossified with the proximal element.

A very large terminal phalange (no. 19407) from Little High Rock Cañon (figs. 45a to 45c) evidently represents digit two of the anterior limb. It is high and narrow with a deep terminal cleft. A large subungual process is developed, and a large foramen is present on the posterior-lateral angle of the process which remains entire. The nature of the subungual process and of the accompanying foramen suggests very strongly the characters of the corresponding region in the terminal phalanges of the gravigrade edentates. The deep terminal cleft and the entire absence of any indication of a hood around the basal region of the claw show that this form is a chalicothere and not a gravigrade.

A somewhat similar but smaller and less compressed claw from Virgin Valley shows the subungual process less developed. There is in this specimen a large foramen on one side of the basal process, and a much smaller one on the opposite side. The character of the inferior region of the claw in these specimens is not unlike that of the specimen of *Macrotherium grande* figured by Deperet,[20] though the subungual process appears to be somewhat deeper in the specimen from Little High Rock Cañon.

A third claw (no. 10723) from Virgin Valley (figs. 44a and 44b) is relatively shorter and thicker and the cleft is deeper. The subungual process is scarcely developed and the basal foramina are small. This claw is possibly from the posterior limb. It was associated with the astragalus and calcaneum.

The astragalus, no. 19404 (fig. 42), is very short, being sharply truncated anterior to the trochlea, so that there is no neck. The anterior articular surface shows no distinct articular facet for the cuboid. The trochlear surface is broad and the groove fairly deep.

In the calcaneum, no. 19405 (fig. 41) the sustentacular region is very prominent, though the sustentacular face for articulation with the astragalus is not extraordinarily large. The external face for articulation with the astragalus extends forward almost to the anterior end of the bone. It also reaches inward to join the sustentacular face, so that the interosseous ligament did not separate them.

[20] Deperet, C., Arch. Mus. Lyon, t. 5, pl. 4, fig. 7a, 1892.

With the material available one does not seem to be justified in definitely referring the Virgin Valley chalicotheres to any of the known species. Especially is this difficult owing to the fragmentary nature of the types of the species, *M. distans* and *M. senex*, described by Marsh from the John Day region, which is separated by only a short distance from Virgin Valley. The Virgin Valley form is presumably very near if not identical with some of the forms already described. If some of the material from the John Day region should prove to have been derived from the Mascall formation there would be reason to suspect that the Virgin Valley species is nearly related to it. If all of the material from the John Day Valley is from the John Day formation specific identity is improbable.

Occurrence: Virgin Valley Beds, localities 1065 and 1095, Virgin Valley, Humboldt County, Nevada; also from High Rock Cañon and Little High Rock Cañon, Humboldt County, Nevada.

PROBOSCIDEA

MASTODON (TETRABELODON ?, sp.)

Remains of proboscideans were found frequently both at Thousand Creek and Virgin Valley. In Virgin Valley they were obtained in the highest horizons in which fossil remains were seen, and also occurred well down in the section, though possibly not at the lowest horizon at which collections were made.

The Virgin Valley specimens comprise a number of scattered limb-bones, and several cheek teeth with a small part of a tusk. All of this material represents a form of the mastodon type, but the specimens are not perfect enough to permit an exact determination. The size of the tooth fragments indicates that the individuals were quite large. A few fragments associated with a specimen found low down in the section at Virgin Valley seem to show an enamel band along the side of a tusk. A series of almost unworn teeth which had broken down and scattered over many square yards of a steep hillside in the Virgin Valley Beds of High Rock Cañon was partly recovered and pieced together, so that a portion of the form of the molars can be represented in figures 46 and 47.

In the Thousand Creek Beds proboscidean remains are not uncommon, though nearly always scattered or badly fractured. A proboscidean jaw with a portion of the skull (pl. 33) found by Miss

Alexander in the beds at Thousand Creek was the only specimen obtained that represented more than an isolated element of the skeleton. This skull had evidently been broken before it was buried, and the part remaining had been unevenly preserved. The teeth and a portion of the jaw were preserved without alteration, though intersected by very numerous fractures. The remaining part of the skull had broken down to a soft pulpy mass which could not be satisfactorily preserved. The dentition of this specimen
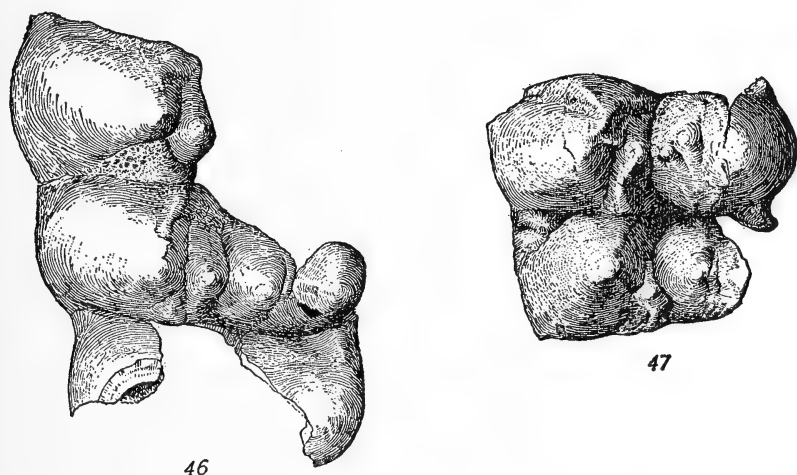
FIGS. 46 AND 47. Mastodon (*Tetrabelodon ?*, sp.). Portions of cheek teeth. No. 19445, × ½. Virgin Valley Beds, High Rock Cañon, Nevada.

seems to be of a fairly advanced type, and may represent a tetralophodont form. Other material from the Thousand Creek Beds evidently represents the same form as the specimen found by Miss Alexander.

SUIDAE

PROSTHENNOPS(?), sp.

A number of associated bones and teeth (no. 11876) from Thousand Creek represent a large dicotyline form probably most nearly allied to *Prosthennops*. No exact comparison with the species of that genus can be made as the parts present in the Nevada material are not well preserved in the available *Prosthennops* material.

Two upper premolars are present. The smaller one (*a*, fig. 53)

is nearly triangular in cross-section. It supports a large external and a slightly swollen internal tubercle. There is a minute median anterior tubercle, but otherwise the cingulum is not well developed on the anterior side of the tooth. On the posterior border there is a well-developed transverse shelf. This tooth is less advanced than P² of *Tayassu* in that it possesses but a single tubercle on the outer border.

The other premolar (*b*, fig. 53) is nearly quadrate in cross-section.
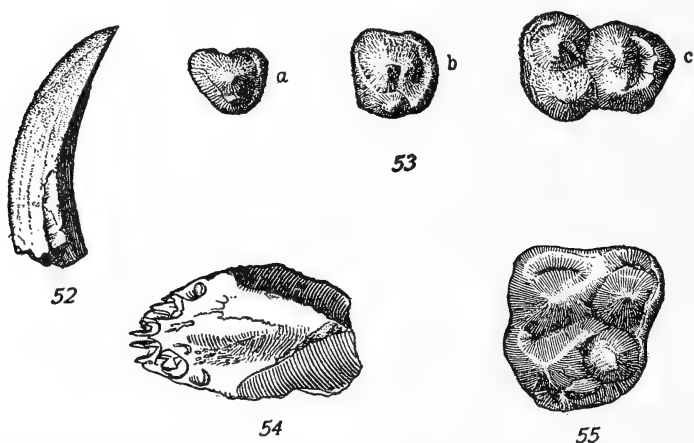
FIGS. 52 TO 53*a*. *Prosthennops*(?), sp. No. 11876. Thousand Creek Beds, Thousand Creek, Nevada.

FIG. 52. Inferior canine, × ½.

FIG. 53*a*, P²?, natural size. Fig. 53*b*, P³ or P⁴, tooth tilted slightly toward inner side in the figure, natural size. Fig. 53*c*, M³, natural size.

FIG. 54. Portion of mandible of a large suilline. No. 19416, × ½. Thousand Creek Beds, Thousand Creek, Nevada.

FIG. 55. *Thinohyus*(?), sp. M³. No. 11854, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

The tubercles of the anterior pair are nearly equal. The postero-external tubercle or tritocone is slightly smaller than the proto-cone. In the postero-internal angle three tubercles are developed. The anterior of these three may represent the tetartocone, the other two belonging to the posterior shelf of the cingulum. This tooth corresponds in development approximately to P³ of *Tayassu*. The posterior-internal tubercle is smaller than in that form, but the tooth as a whole comes as near the quadrate form as P³ of *Tayassu*.

A single well-preserved premolar tooth almost identical in form

and dimensions with the one just described was found connected with a fragment of the jaw at another locality in the Thousand Creek region. In this specimen the enamel is well preserved but the tubercles are slightly worn. The cingulum is well developed on the anterior side of the protocone and deuterocone, and on the outer side of the tritocone. The fragment of the maxillary shows immediately above the tooth a strongly-marked shoulder which formed the floor of the depression leading to the infraorbital foramen as in *Tayassu*. The small foramina anterior to the depression leading to the infraorbital foramen are immediately above the exposed posterior root of the tooth. Judging from the position of the infraorbital foramen in *Tayassu* and *Prosthennops*, unless the infraorbital foramen was here situated considerably farther back than in these forms, this tooth is possibly P³ rather than P⁴.

The smaller of the two premolars is evidently more advanced than the P² which must have occupied the very small alveolus for this tooth shown in the figure of *Prosthennops crassigenis* figured by Matthew and Gidley.[21]

The larger premolar has but three roots instead of four as in P⁴ of *P. crassigenis*, but the quadrate form is as well developed as in that tooth.

Considering the smaller premolar as either P² or P³ and the larger as either P³ or P⁴, and taking all of the combinations possible, the Thousand Creek species is less advanced than *Tayassu* or *Mylohyus*, but more advanced than *Platigonus*. A fully satisfactory comparison of this nature with *Prosthennops* is not possible. If the smaller tooth of the Thousand Creek specimen represents P³, *Prosthennops crassigenis* is apparently more advanced. If this tooth is P², as seems possible from the situation of the larger premolar with reference to the infraorbital foramen, the stage of evolution of the premolars is approximately the same in the two forms or slightly more advanced in the Thousand Creek species. With the exception of possible differences in the premolars, to which reference has just been made, the Thousand Creek specimen approaches *Prosthennops* more closely than to the other American genera of the Suidae.

The third upper molar (*c*, fig. 53) is the only molar preserved complete. The enamel is much corroded so that the tuberculation

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[21] Matthew, W. D., and Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 20, p. 266, fig. 14, 1904.

is not entirely clear, but the tooth appears to be of the dicotyline type.   There is a small heel developed on the cingulum behind the hypocone and metacone.   The dimensions of this tooth are near those in *Prosthennops crassigenis*.

A large lower canine (fig. 52) occurring with this individual is triangular in cross-section with a faintly expressed ridge on the middle of the outer face.

MEASUREMENTS

No. 11876

P^2, anteroposterior diameter.. 10.   mm.
P^2, transverse diameter... 8.4
P^3, anteroposterior diameter 11.2
P^3, transverse diameter.. 10.8
M^3, anteroposterior diameter...................................... 21.2
M^3, transverse diameter.. 15.3

No. 11884

P^3, anteroposterior diameter....................................... 10.6 mm.
P^3, transverse diameter... 11.

Other remains accompanying this specimen include small portions of the skull, a calcaneum, and the distal portions of two metapodials. One of the metapodials shows a flattened lateral surface above the distal end, indicating close contact with the metapodial paired with it.

THINOHYUS(?), sp.

A large upper molar (no. 11854, fig. 55) from Virgin Valley shows considerable resemblance to the form of M^3 in *Thinohyus* occurring in the John Day Beds.   The greatest transverse diameter nearly equals the anteroposterior, as in M^2, but the posterior region is narrower than the anterior, and the posterior shelf on the cingulum is more prominent than on any of the molars excepting M^3.

This tooth represents a large species, presumably belonging in the hyotherine division of the Suidae rather than in the later and more specialized dicotylines.

MEASUREMENTS, M^3?.   No. 11854

Greatest anteroposterior diameter.................................. 21.   mm.
Greatest transverse diameter....................................... 20.2

OREODONTIDAE

MERYCHYUS(?), sp.

Two molar teeth from Virgin Valley furnish the only evidence of oreodonts from the deposits of this region.

One specimen, no. 12606 (fig. 48), is an upper molar two. This tooth is very near the stage of development of *Eporeodon*, but the crown tends to be slightly more hypsodont and the mesostyle more sharply narrowed anteroposteriorly. At the point where the horns of the hypocone and protocone crescents are united, the posterior horn of the protocone crescent is a little wider than the anterior horn of the hypocone crescent.

There is only a suggestion of ribs on the outer side of the paracone and metacone. The cingulum is well developed on the anterior
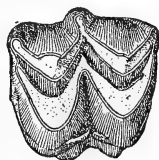
FIG. 48. *Merychyus*, sp. M². No. 12606, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 49. *Merychyus*, sp. M₃. No. 11825, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

side of the protocone crescent, and between the protocone and hypocone. It extends around the inner border of the protocone as a faint ridge. The cingulum is interrupted on the inner side of the hypocone, but is represented by a weak shelf on the posterior side of the hypocone crescent. Faint shelves are present on the cingulum of the outer side of the paracone and metacone.

A lower molar three, no. 11825 (fig. 49), shows a weak median style and only faint indications of ribs on the middle of the inner side of the two inner crescents. A shelf is developed on the cingulum only on the anterior side of the tooth. The posterior lobe is largely broken away, but enough of it is present to indicate that it was large, and the inner face seems not to have turned very far outward and backward away from the plane of the inner side of the anterior portion of the tooth.

MEASUREMENTS

M², anteroposterior diameter measured on outer side................ 19.2 mm.
M², transverse diameter measured at base across protocone........... 18.1
M₃, anteroposterior diameter along metaconid and entoconid crescents,
  measured on inner side...................................... 18.8
M₃, transverse diameter measured across protoconid and metaconid
  crescents.. 11.4

CAMELIDAE

Numerous fragmentary remains of representatives of the Camelidae were found in the exposures at Thousand Creek, and somewhat less abundantly at Virgin Valley. Unfortunately the material that has been obtained consists only of scattered bones with small fragments of the skull and a few teeth. The foot-bones represented show a considerable range in size, and indicate the presence of at least two forms at Thousand Creek, and two at Virgin Valley. One of the species at Thousand Creek included individuals of very large size, probably representing *Pliauchenia*. At Virgin Valley there was also a large form and a much smaller species. With the scattered limb elements available it is not possible to make a definite determination of any of the forms represented.

Judging from the quantity of camel remains seen, these animals must have been very common in the fauna of this region during the deposition of the Thousand Creek Beds, and also formed an important part of the Virgin Valley fauna.

An isolated third lower molar, no. 12765 (figs. 50*a* and 50*b*), from Thousand Creek represents a form that resembles *Auchenia* in the presence of a prominent buttress or pillar on the anteroexternal angle of the tooth. This buttress is also well-marked in *Camelus americanus* described by Wortman[22] from the Pleistocene of Hay Springs. The anteroexternal buttress is possibly a little stronger than in *C. americanus*, but is not as well developed as in *Auchenia lama*. The dimensions of the tooth from Thousand Creek are greater than in the type of *C. americanus*.

MEASUREMENTS
No. 12765

M₃, anteroposterior diameter..................................... 35.9 mm.
M₃, transverse diameter across protoconid......................... 12.5

C. americanus, Hay Springs

M₃, anteroposterior diameter estimated from figure published by Wortman... 29. mm.

[22] Wortman, J. L., Bul. Am. Mus. Nat. Hist., vol. 10, p. 133, 1898.

A portion of a skull comprising the premaxillaries and a part of the maxillaries from Thousand Creek (fig. 51) represents a camel about as large as the existing *Camelus bactrianus*. The posterior ends of the premaxillaries are truncated on both sides in such a way as to suggest that they were covered by the anterior ends of the nasals. I^1 and I^2 are absent, P^1 was large. At a distance behind P^1, which exceeds slightly the distance between the canine and P^1, there is a small alveolus for a premolar which is presumably P^2.
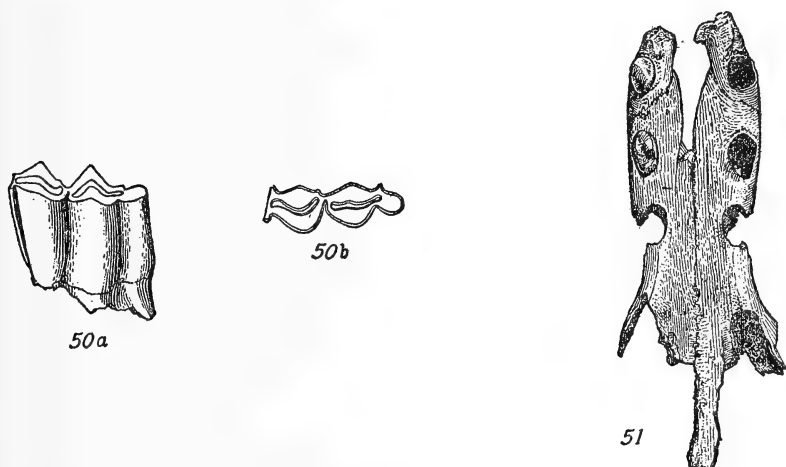
FIGS. 50*a* AND 50*b*. Camel, compare *Camelus americanus* Wortman. M_3. No. 12765, $\times \frac{1}{2}$. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 50*a*, lateral view; fig. 50*b*, occlusal view.

FIG. 51. Cameloid. Premaxillary and portion of maxillary. No. 19416, $\times \frac{1}{4}$. Thousand Creek Beds, Thousand Creek, Nevada.

CERVIDAE

BLASTOMERYX MOLLIS, n. sp.

Type specimen no. 11564, Univ. Calif. Col. Vert. Palae. from lower Virgin Valley Beds, Virgin Valley, Nevada. Cotype no. 11567 from the same locality.

Several jaws and teeth from Virgin Valley and High Rock Cañon represent a species of *Blastomeryx* differing only slightly from *B. primus* and *B. olcotti* from the Upper Rosebud Beds of South Dakota. The tooth row is slightly longer than in either *B. primus* or *B. olcotti*. P_1 is not represented. On one specimen from Virgin Valley (no. 11567, figs. 57*a* and 57*b*) a space half the anteroposterior

diameter of P_2 is present immediately in front of that tooth but without an alveolus for P_1, so that if P_1 was present it was not situated close to P_2 as in *B. olcotti*.   On a specimen from High Rock Cañon (no. 12609, figs. 58a and 58b) a still larger space anterior to P_2 shows no alveolus for P_1. P_3 and P_4 are triangular in cross-section as in *B. olcotti* and have otherwise much the same form as in that species.

In the slightly greater length of the tooth row, relatively larger size of the premolars or smaller size of M_3 and absence of P_1 immediately anterior to P_2 the Nevada form differs from *B. olcotti*.
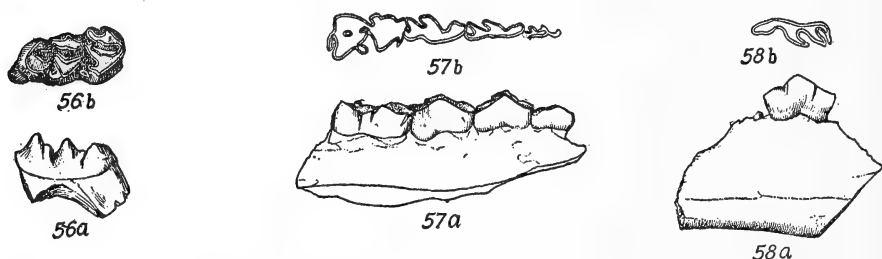
FIGS. 56a AND 56b. *Blastomeryx mollis*, n. sp. M_3. No. 11565, natural size. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 56a, lateral view; fig. 56b, occlusal view.

FIGS. 57a AND 57b. *Blastomeryx mollis*, n. sp. Fragment of mandible with inferior dentition. No. 11567, natural size. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 57a, lateral view; fig. 57b, occlusal side.

FIGS. 58a AND 58b. *Blastomeryx mollis*, n. sp. Fragment of jaw with P_3 and alveolus of P_2. No. 12609, natural size. Virgin Valley Beds, High Rock Cañon, Nevada. Fig. 58a, inner side of jaw fragment with P_3; fig. 58b, occlusal view of P_3.

From *B. primus* it differs in the triangular rather than oval form of P_4, in a slightly longer tooth row, and probably in the anteroposterior diameter of the premolars.

The stage of advance of this species is close to that of *B. primus* and *B. olcotti*, and it may possibly be united with one of these forms when more material is available for study.

<div align="center">MEASUREMENTS</div>

	No. 11565	No. 10661	No. 11567	No. 11566	No. 12609	No. 11564
Length, anterior side P_2 to posterior side M_1..........			31.3 mm.			
P_2, anteroposterior diameter...			5.4			
P_3, anteroposterior diameter...			7.8		8.5	7.8
P_4, anteroposterior diameter...	8.9	9.1	8.5	8.8	8.8	
M_1, anteroposterior diameter..	9.	9.2	9.5	8.8	8.5	

	No. 11565	No. 10661	No. 11567	No. 11566	No. 12609	No. 11564
M_2, anteroposterior diameter..			10.3	10.		9.8
M_3, anteroposterior diameter..	13.8					13.
M_3, transverse diameter......						7.3
Length, anterior side P_3 to posterior side M_3..........						45.5
Height of mandible below P_2...					14.3	
Height of mandible below M_2..					14.9	14.2

DROMOMERYX, sp. *a*, near BOREALIS (Cope)

Several jaws and teeth from Virgin Valley correspond very closely to forms which have been referred to *Palaeomeryx*, and have recently been designated as a new genus, *Dromomeryx*, by Douglass.[23]

A single upper molar, described and figured by Gidley,[24] was referred by him tentatively to *Palaeomeryx(?) borealis*.

Several fragments of jaws with teeth, and a lower molar, M_3 (fig. 62), belong to an animal about as large as that represented by the upper molar described by Gidley. On specimen no. 12601 the palaeomeryx fold is well marked on M_1, and is faintly shown on M_2. The basal tubercle between the protoconid and hypoconid is large. There is a distinct anterior basal ridge as in the specimens from Snake Creek recently referred to *Palaeomeryx* by Matthew and Cook.[25]

The anteroposterior dimension of M_3 is near that of the *Palaeomeryx* species from Snake Creek. On this tooth the palaeomeryx fold is only suggested, the basal tubercle between the protoconid and hypoconid is large, and there is a faint basal tubercle between the hypoconid and the heel.

Numerous scattered limb elements from the Virgin Valley Beds represent a form of *Dromomeryx* near *borealis* (Cope). The best preserved specimen is one from locality 1095, in which the larger part of an anterior limb is represented. In this specimen the proportions of the limb differ slightly from those given by Douglass for *D. borealis*. This is especially true of the metapodial. In the limb figured (fig. 60*a*) a section of the middle of the bone was missing when the specimen was discovered. Without considering the

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[23] Douglass, Earl, Ann. Carneg. Mus., vol. 5, p. 461, 1909.
[24] Gidley, J. W., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 241, 1908.
[25] Matthew, W. D., and Cook, H. J., Bull. Am. Mus. Nat. Hist., vol. 26, p. 408, 1909.
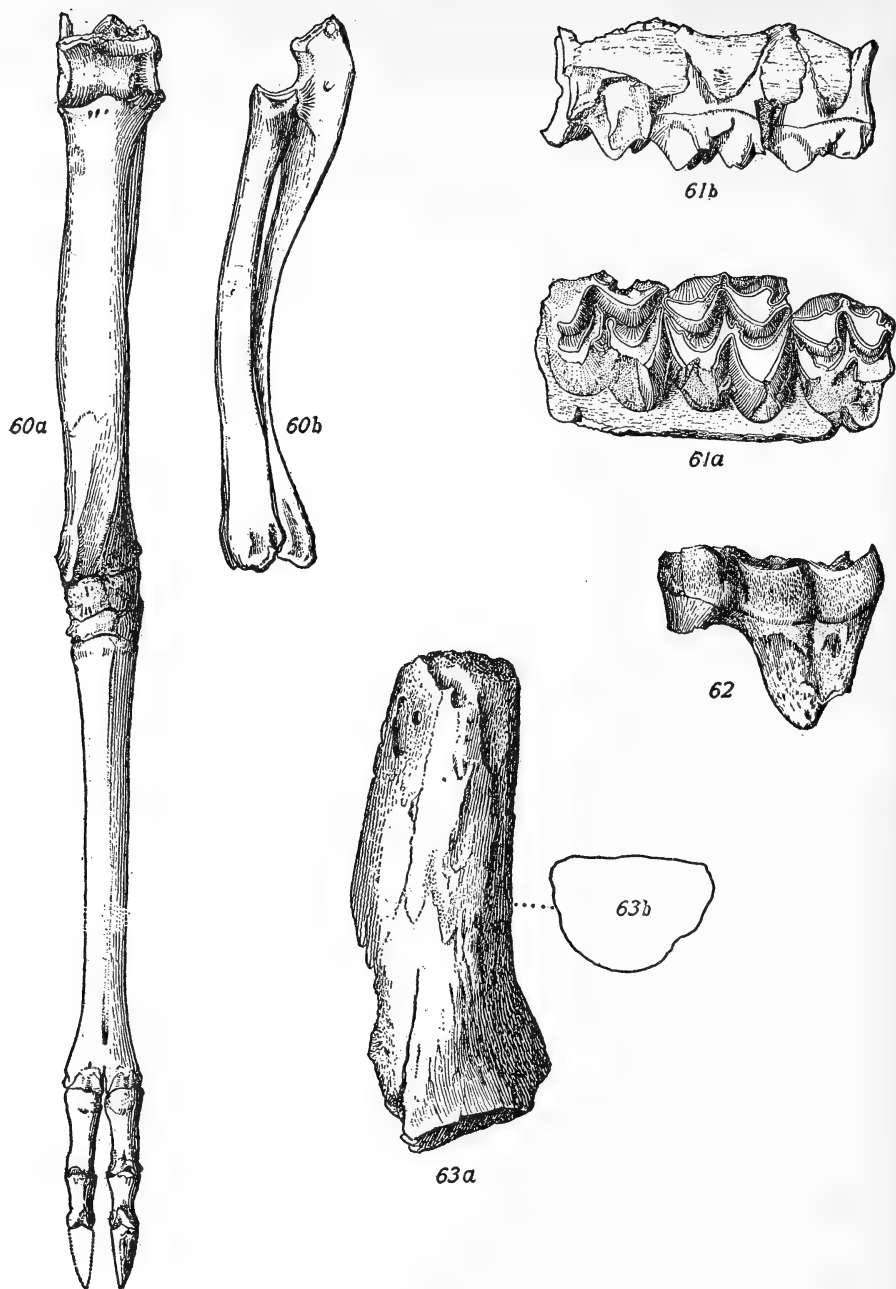
Figs. 60a and 60b. *Dromomeryx*, sp. *a*, near *borealis* (Cope). Anterior limb. No. 19417, × ¼. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 60a, anterior view of limb; Fig. 60b, lateral view of radius and ulna.

Figs. 61a and 61b. *Dromomeryx*, sp. *b*. Superior molar series. No. 11470, natural size. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 61a, occlusal view; fig. 61b, outer view.

Fig. 62. *Dromomeryx*, sp. *a*, near *borealis* (Cope). M₃. No. 11748, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

Figs. 63a and 63b. *Dromomeryx*, sp. Basal region of horn. No. 11628, × ½. Virgin Valley Beds, Virgin Valley, Nevada. Fig. 63a, outer side; fig. 63b, cross-section.

missing fragment the length of this bone is greater and the form more slender than that of the anterior metapodial figured by Douglass. Making a small allowance for this fragment the length of the Virgin Valley specimen is noticeably greater and the slenderness more apparent.

<div align="center">

MEASUREMENTS

No. 19417
</div>

Radius.
>   Greatest length along anterior border......................... 250. mm.
>   Greatest diameter across distal end........................... 47.6

Digit IV.
>   Phalange I, greatest length.................................. 45.5
>   Phalange II, greatest length................................ 29.
>   Phalange III, greatest length............................... 39.5

<div align="center">No. 10676</div>

M³, anteroposterior diameter.................................... 19.6

<div align="center">No. 19444</div>

Upper molar, anteroposterior diameter.......................... 21.2

<div align="center">No. 11748</div>

M₃, anteroposterior diameter................................... 30.

<div align="center">

DROMOMERYX, sp. *b*
</div>

A portion of an upper jaw with molars 1 to 3 (no. 11470, figs. 61*a* and 61*b*) is from a form referable to *Dromomeryx*, but considerably smaller than the specimen examined by Gidley. This specimen represents an individual quite certainly distinct from *D. borealis* (Cope). On the upper molars of this specimen there is a prominent shelf developed upon the cingulum on the outer wall of the paracone in a situation in which no similar shelf appears on the figured specimens which the writer finds referred to *Palaeomeryx* or *Dromomeryx*.

The shelf on the cingulum is strongest next the mesostyle, and disappears opposite the middle of the outer side of the paracone. A similar shelf appears to be shown on the larger form described by Gidley, but it seems to the writer to be due in some part at least to a fracture of the specimen. On two other upper molars of the larger form from Virgin Valley there is no suggestion of this shelf.

The possibility that the first two of the upper molars of no. 11470 described above represent the milk dentition has been considered, but the evidence does not seem to indicate that this is the case. Even if this were true, it should be noted that the shelf of the cingulum described above is shown on the most posterior tooth, as well

as on the others, and would still be a characteristic of the permanent dentition.

A shelf of the type seen in the smaller form is barely suggested on a large worn specimen of *Dromomeryx* from the Mascall Beds of Oregon.

<div align="center">MEASUREMENTS</div>

<div align="center">No. 11470</div>

Length, anterior side M^1 to posterior side M^3........................ 44.3 mm.
M^1, anteroposterior diameter..................................... 14.3
M^1, transverse diameter... 18.5
M^2, anteroposterior diameter..................................... 16.0
M^2, transverse diameter... 20.3
M^3, anteroposterior diameter..................................... 15.8
M^3, transverse diameter... 19.0

<div align="center">DROMOMERYX, sp.</div>

In the collections from Virgin Valley there is a specimen consisting of the basal portion of a large horn-core, no. 11628 (figs. 63*a* and 63*b*), the form of which shows close resemblance to *Dromomeryx*. The portion of the horn present is nearly straight, with only a suggestion of curvature, and narrows gradually from the base upward. The basal portion of the core is triangular in cross-section. The section of the terminal region seems to have been approximately oval. The texture of the surface of the core is in general more dense or less pitted than in *Aplocerus*.

Though it is not possible to make a definite determination of the affinities of the form represented by this specimen, it is probable that it represents a large, antelope-like type similar to *Dromomeryx*.

<div align="center">ANTILOCAPRIDAE</div>

<div align="center">MERYCODUS, near FURCATUS (Leidy)</div>

The genus *Merycodus* is represented by a number of antlers (fig. 66) from Virgin Valley. The best preserved antler from Virgin Valley extends upward to a height of 110 mm. above the base without branching. The middle of the burr is 25 mm. above the base. It seems to resemble *M. furcatus* most nearly, though the several specimens of antlers known average a little smaller than *M. furcatus*, and the burr is a little higher.

MERYCODUS NEVADENSIS, n. sp.

Type a lower jaw with M_1 to M_3, no. 12608, Univ. Calif. Col. Vert. Palae. from High Rock Cañon, Nevada. A slender antler from the same locality.

Lower cheek-tooth series less than 45 mm. in length. M_1 to M_3
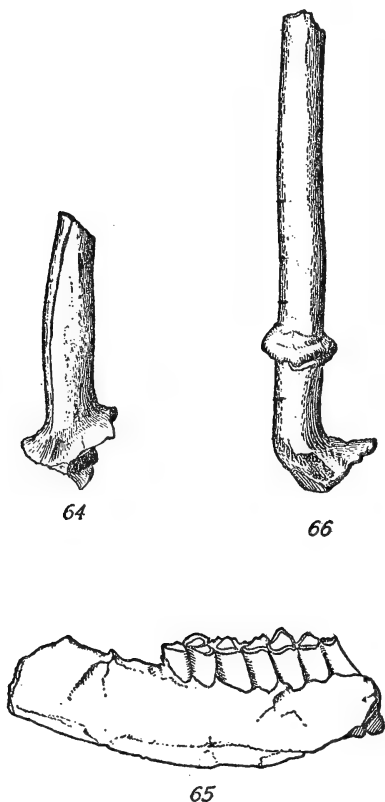
FIG. 64. *Merycodus nevadensis* n. sp.(?). Basal region of horn. No. 12524, × ½. High Rock Cañon, Humboldt County, Nevada.

FIG. 65. *Merycodus nevadensis*, n. sp. Portion of lower jaw with dentition. No. 12608, type specimen, natural size. High Rock Cañon, Humboldt County, Nevada.

FIG. 66. *Merycodus*, near *furcatus* (Leidy). Basal region of horn. No. 11319, × ½. Virgin Valley Beds, Virgin Valley, Nevada.

inclusive, 25 mm. Molars distinctly hypsodont, considerably compressed laterally, M_3 with small heel.

The lower jaw fragment (fig. 65) from High Rock Cañon shows little of the form of the mandible, excepting its height below the premolars. The molar teeth are the only ones present, but a liberal

estimate of the length of the cheek-tooth series from P_2 to M_3 indicates that this form was considerably smaller than *M. furcatus*, *M. necatus*, and *M. osborni*. The molars are distinctly hypsodont, without styles between the outer pillars, and are rather sharply compressed. On M_3 the heel is a little smaller than the middle segment of the tooth.

MEASUREMENTS, No. 12608

Approximate height of mandible below P_2.......................... 11.2 mm.
Length, M_1 to M_3 inclusive.. 25.3
M_1, anteroposterior diameter...................................... 6.8
M_1, transverse diameter of posterior segment........................ 3.8
M_2, anteroposterior diameter...................................... 7.6
M_3, anteroposterior diameter...................................... 11.5
M_3, transverse diameter of middle segment........................ 3.7

An antler obtained at High Rock Cañon (fig. 64) is slender, slightly swollen a short distance above the base, and without traces of a burr. Like the lower jaw fragment, the antler is smaller than in *M. furcatus*, but may represent a young animal. It is considerably compressed in a plane inclined about 45° away from the anteroposterior plane of symmetry of the skull, and shows a distinctly marked concavity at the base of the horn immediately behind the orbit. So far as can be determined there seems reason for suspecting that the antler of the form represented by this specimen was not at any stage entirely similar to those of the previously described forms.

This form seems to differ so far from the known species as to make a specific correlation with any of them inadvisable, and the name *Merycodus nevadensis* is tentatively applied to it.

SPHENOPHALUS NEVADANUS Merriam

S. nevadanus Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 325, 1909.

This species was based on a number of specimens representing portions of the skull with horn-cones. In the original description it was characterized as follows:

"Frontals not cavernous at the base of the horns. Horns situated on the upper posterior region of the orbits, sloping backward, slightly outward, and tilted upward at an angle between twenty-five and thirty degrees from the plane of the frontals above the orbits. Horn-cores flattened in a plane extending backward

and inward from the orbits.   A short distance above the base the horn-cores flare or widen slightly in the direction of greatest diameter in cross-section.   Outer anterior edge of the horn-core arising over the upper posterior region of the orbit, and swinging backward with a suggestion of a twist.   Surface of the horn-core comparatively smooth, with a few pits or irregularities.   Texture of the outer portion of the horn-core solid.   Supraorbital foramina present in front of the middle of the antero-medial side of the base of the horn-cores."

Horn-core.—In the collections which have been examined since the original description of this species a number of fragmentary specimens have been obtained which represent this form.   One of these, no. 12537, represents the base of a horn-core (figs. 67a and 67b), which is wider antero-posteriorly, but much thinner transversely, than the type specimen.   It also differs somewhat from the
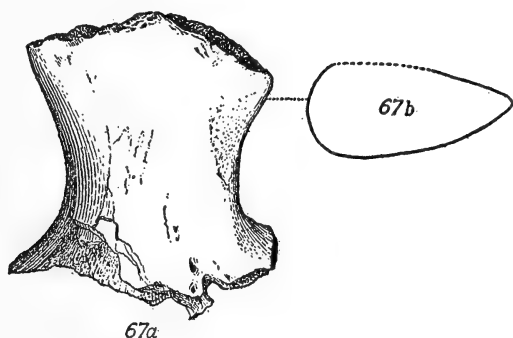
FIGS. 67a AND 67b.   *Sphenophalos nevadanus* Merriam.   Basal region of horn.   No. 12537, × ½.   Thousand Creek Beds, Thousand Creek, Nevada.   Fig. 67a, medial side of horn; fig. 67b, cross-section of horn.

type in the nature of the region on the posterior side of the base of the horn-core.   In the type-specimen, this region is very broadly rounded or nearly flat transversely.   In no. 12537 the posterior basal region is relatively much narrower, and a low longitudinal keel is developed on the middle of the posterior surface.

In this specimen the tendency of the horn-core to flare antero-posteriorly a short distance above the base is more distinctly shown than in the type material.   This is possibly due in part to the slightly better preservation of the anterior margin in this specimen. Though the differences between this specimen and the type of *S. nevadanus* are considerable, it quite certainly represents the same general group and may be referred to this species.

In the thinness of the horn and in the tendency to develop a low

median ridge on the surface of the narrower posterior side of the horn-core, this specimen approaches the modern *Antilocapra* a little more closely than does the type material.   As nearly as can be determined from the fragmentary specimen, the other characters which separate the type of *Sphenophalos* from *Antilocapra* are as marked here as in the type specimen.

MEASUREMENTS OF THE HORN-CORES

	Pronghorn No. 8298*	No. 11887	No. 11888	No. 12537
Anteroposterior diameter at narrowest point above the base.................	41.3 mm.	41.7	36.5	44.8
Greatest anteroposterior diameter........	50.	51.5	43.	60.
Transverse diameter measured at the same point as the least anteroposterior diameter...........................	23.9	33.	28.4	27.

* Calif. Mus. Vert. Zool.

Dentition.—In the collections thus far obtained in the Thousand Creek region there are quite a number of long-rooted molar teeth of antelope-like forms that show a considerable range in size.   Some of the specimens represent animals as large as the existing *Antilocapra*, others come from much smaller forms.   It is probable that some of these teeth represent *Sphenophalos nevadanus*.   All of the cheek teeth of antelopes from the Thousand Creek region are closely similar in form and structure to those of the Recent *Antilocapra*.   Some of the larger teeth which seem most appropriate in size to accompany the skull of *Sphenophalos* are noticeably similar in form to the corresponding teeth of *Antilocapra*.

The upper and lower molars are all long-rooted, reaching almost, if not quite, to the stage of development of the Recent *Antilocapra* in this particular.

Two upper molars from Thousand Creek resemble the corresponding teeth of the Recent *Antilocapra* in form and size.   A third upper molar, no. 12610 (figs. 70*a* and 70*b*), is similar to M^3 of *Antilocapra*.   It differs mainly in the shortness of the wing or lobe developed on the posterior side of the tooth.   A hypsodont lower molar M_2, no. 12604 (figs. 71*a* and 71*b*), has the same anteroposterior diameter as M_2 of *Antilocapra*, but is noticeably narrower transversely.   These teeth may presumably be referred to *Sphenophalos*. They probably represent the type species, *S. nevadanus*, which was
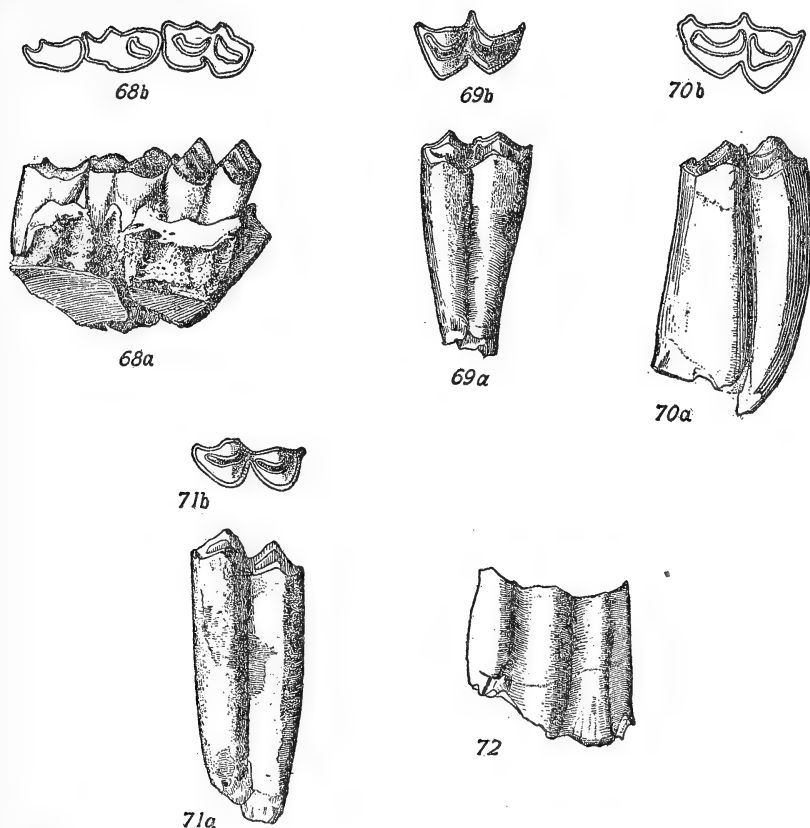
Figs. 68a and 68b. *Sphenophalos* or *Ilingoceros*, sp. P³ to M¹. No. 12613, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 68a, inner view; fig. 68b, occlusal view.

Figs. 69a and 69b. *Sphenophalos* or *Ilingoceros*, sp. Upper molar. No. 12605, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 69a, outer view; fig. 69b, occlusal view.

Figs. 70a and 70b. *Sphenophalos nevadanus* Merriam(?). M³. No. 12610, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 70a, inner view; fig. 70b, occlusal view.

Figs. 71a and 71b. *Sphenophalos* or *Ilingoceros*. Inferior molar. No. 12604, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 71a, outer view; fig. 71b, occlusal view.

Fig. 72. *Sphenophalos nevadanus* Merriam(?). Outer side of M₃. No. 19418, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

represented by individuals fully as large as the living pronghorns of the Nevada region.

From one place at locality no. 1100 a considerable number of fragments of teeth were found which include a number of pieces of upper molars like those referred tentatively to *Sphenophalos*, and with these an interesting fragment representing the wall of a third lower molar. This specimen (fig. 72) shows a tooth comparable in size to M_3 in *Antilocapra*, but differing from that form in the nature of the third or posterior lobe. In *Antilocapra* the posterior lobe is normally sharply divided into two pillars by a deep vertical groove in the outer wall. In *Capromeryx* this groove is apparently barely indicated near the lower end of the tooth, and in *Merycodus* it is unrepresented. The specimen from Thousand Creek is distinctly different from the existing *Antilocapra* in that the external longitudinal groove on the posterior lobe, though clearly shown, marks only a weak separation compared with the sharply-marked constriction in *Antilocapra*.[26] This tooth is presumably to be referred to *Sphenophalos*, though it may represent the twisted-horned form *Ilingoceros*. It shows a stage of evolution tending toward the *Antilocapra* type, but a little less advanced than in that genus.

[26] In one of two specimens of *Antilocapra* available from northern Nevada there is a notable exception to the type of M_3 normal in this form. In this specimen (no. 8299 Univ. Calif. Mus. Vert. Zool.) the permanent molars are present, and the last milk premolar is just on the point of dropping out. In both rami M_3 is a three-lobed tooth, but the posterior lobe shows no indication of a division into two parts by a longitudinal external groove. The posterior lobe in this specimen is about as large as the portion of the posterior lobe anterior to the external longitudinal groove in the typical specimens. No suggestion of an external longitudinal groove is present, even low down on the tooth. The writer is not entirely clear as to the significance of this variation of M_3. If this character should appear in other specimens, and at the same time be coupled with other variations from the normal type, it might have some claim to importance as a specific distinction. In this specimen the peculiar character of M_3 is accompanied by an apparent slight modification of the character of the posterior side of M^3 and by a weaker development of the external styles of the upper molars. The deviation of the upper molars from the type of tooth shown in other specimens available may be due in part to difference in degree of wear, but this factor does not seem competent to account for the whole difference. Unless more material of the same nature as this specimen comes to hand, one would hardly seem justified in considering the variation shown here as more than an individual abnormality. Even if classed as an individual peculiarity, it may be found to have some significance in the interpretation of the history of variation or differentiation in this group, but our knowledge of the meaning of such irregularities in the growth of individuals is yet too imperfect to give us a clue as to the interpretation of this case.

MEASUREMENT OF TEETH OF ANTELOPE-LIKE FORMS REFERRED IN PART
TO SPHENOPHALOS

		Capromeryx	*Antilocapra*
M_1, anteroposterior diameter.....................		9.3 mm.	12.7
M_1, transverse diameter...........................		5.1	6.7
	No. 12604		
M_2, anteroposterior diameter.....................	14.7	11.0	14.7
	No. 12612		
	13.		
	No. 12604		
M_2, transverse diameter...........................	6.9		7.7
	No. 12612		
	6.2		
M_3, anteroposterior diameter.....................		16.5	24.
M_3, transverse diameter...........................		5.6	8.
	No. 12613		
M^1, anteroposterior diameter.....................	12.1		13.5
	No. 12603		
	11.7		
	No. 12613		
M^1, transverse diameter........................	8.4		10.1
	No. 12603		
	9.		
	No. 12605		
M^2, anteroposterior diameter.....................	14.		15.4
	No. 12605		
M^2, transverse diameter...........................	8.5		10.3
	No. 12611		
M^3, anteroposterior diameter.....................	17.5a		17.
	No. 12610		
	17.		
	No. 12611		
M^3, transverse diameter........................	10.5		10.1
	No. 12610		
	10.3		
	No. 12613		
Anterior side P^3 to posterior side M^1..............	30.8		31.5
P^3, anteroposterior diameter.......................	8.4		10.
P^3, transverse diameter...........................	4.8		6.
P^4, anteroposterior diameter.......................	10.4		10.2
P^4, transverse diameter...........................	6.7		7.5
M^1, anteroposterior diameter.....................	12.1		13.5
M^1, transverse diameter........................	8.4		10.1

a, approximate.

Relationships.—As was noted in the original description of
Sphenophalos[27] this form resembles the pronghorn antelopes some-
what in the general form of the horn-core and also in the surface
of the core. The tendency of the horn-cores of the fossil form to
widen anteroposteriorly a short distance above the base is also a
character in which they resemble the horns of the pronghorn. The
horn-cores differ from those of the pronghorn in greater thickness,

[27] Merriam, J. C., *op. cit.*, p. 328, 1909.

more oblique position, slightly more posterior situation, and entirely different topography of the postero-basal region.

Unfortunately we have not been able to obtain material showing the nature of the terminal region of the horns of *Sphenophalos*. The widening of the laterally compressed horn-core not far above the base certainly suggests that the terminal region may have a general resemblance to that of *Antilocapra*.

Of the large Antilocapra-like molar teeth found in the Thousand Creek Beds it seems probable that some of the specimens represent *Sphenophalos*.

Unfortunately the material representing the limbs, arches, and vertebral column of antelope-like forms found in these beds consisted solely of scattered bones, and nothing like a connected skeleton has been recovered. It is, however, well worth considering that none of this material represents forms which differ greatly from *Antilocapra*, and the larger forms are uniformly close to that genus.

Taking into consideration all of the evidence obtained from an examination of the skull material which can be definitely referred to *Sphenophalos*, and with it such evidence as is obtained from examination of the associated remains representing other parts of the skeleton and the dentition, there seems to be much in favor of the view that *Sphenophalos* is a representative of the Antilocapridae, while almost no facts present themselves which seem to contradict this hypothesis.

The difference between the Thousand Creek species and the Recent *Antilocapra* seems to the writer sufficient to require their generic separation, but it would not be surprising to find the general relationship fairly close when better specimens of *Sphenophalos* become available.

ILINGOCEROS SCHIZOCERAS, n. sp.

Type specimen a complete horn-core, no. 11893, Univ. Calif. Col. Vert. Palae. From the Thousand Creek Beds at Thousand Creek, Humboldt County, Nevada.

In the first description of the genus *Ilingoceros*, two types of horn-cores of uncertain specific position were referred to this group as forms B and C. The specimen on which form C was based lacked the distal portion of the horn-core, as was shown in figure six

of the original publication.[28] Since this paper was issued the terminal portion of this horn-core has been found in a small collection made only a few yards from the spot at which the type of form C was collected. The two fractured faces fit together perfectly and there is no possible doubt as to their representing the same horn-core.

Horn-Core.—As shown in figures 73*a* and 73*b*, the portion now

73*a*   73*b*
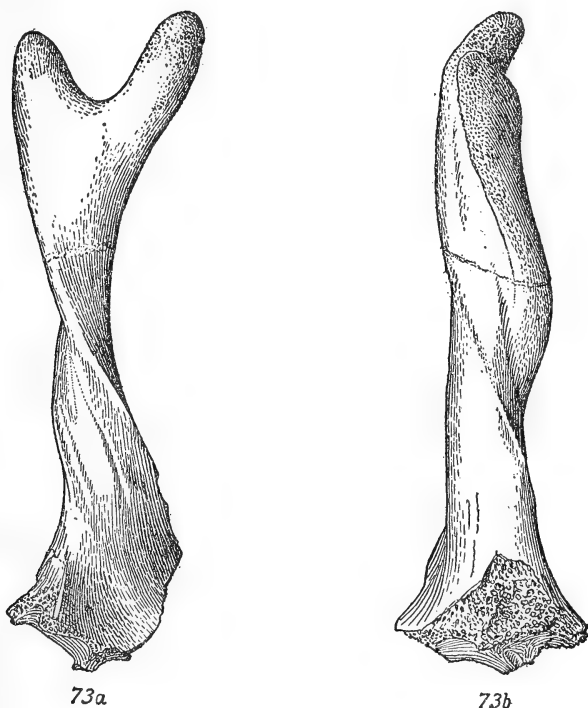
FIGS. 73*a* AND 73*b*. *Ilingoceros schizoceras*, n. sp. Two views of the horn. No. 11893, natural size. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 73*a*, posterior side; fig. 73*b*, inner or medial side.

added to the original specimen carries the horn upward with the same spiral twist and flattened cross-section shown in the lower portion already described. The upper end of the horn, instead of narrowing to a point as in typical antelopes, is widened slightly and is deeply notched so that it ends in two distinct prongs. The terminations of the prongs are obtuse, and consist of much more spongy tissue than the rest of the horn.

[28] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 323, fig. 6, 1909.

The type of horn shown here is quite distinct from that of any form previously described.   While the basal portion resembles that of the strepsicerine antelopes, the terminal region suggests the divided horns of certain forms of *Merycodus*.   There is no suggestion of a burr on the horn, and since the terminal portion of the core is slightly wider than the middle region a sheath horn could not have been shed without splitting.

If this horn-core represents a young animal, it may possibly belong to one of the forms referred to *Ilingoceros alexandrae*.   It was, however, associated with numerous remains of evident adults of a form much smaller than *I. alexandrae*.   Under the circumstances one does not seem justified in arbitrarily referring it to *I. alexandrae*, as that form distinctly differs in several characters.   In *I. alexandrae* the spiral ridge which has its origin on the postero-superior region of the orbit arises anterior to the postorbital process of the frontal.   In this form the ridge arising over the orbit is evidently continuous with the postorbital process.   In *I. alexandrae* the horn is almost circular in cross-section; in this specimen the section is much flattened.   Such fragments of horn-cores of *I. alexandrae* as are available indicate that the horns were considerably elongated, and round in section some distance above the base, having therefore quite a different character from those of this form.

For the present, one seems warranted in separating the type represented by specimen 11893 as a species distinct from *I. alexandrae*. It may be referred to the genus *Ilingoceros*, though it is not entirely certain that it is not also generically different.

The form of horn represented in this specimen suggests relationship with three groups, the Merycodontidae, the Antilopinae and the Antilocapridae.   The resemblance to any known form of the *Merycodus* group is not close.   The burr is entirely absent, the horn-core is strongly twisted, and the distal notching is very shallow.   The shallowness of the notch might be expected in a young individual.   There is, however, some reason for suspecting that this horn may represent a full-grown animal, as it is associated with numerous remains of small antelope-like animals which are evidently adults.   The horns of *Merycodus nevadensis* from the Virgin Valley Beds at High Rock Cañon present as near an approach to the antelope form as has been observed among forms referred to *Merycodus*.

The resemblance of this form to true antelopes of the strepsicerine type has already been commented upon in a former publication.[29] With only the portion of the horn below the tip represented, a relationship to the tragelaphines is unavoidably suggested. Considered in connection with the other forms referred originally to the genus *Ilingoceros*, there seems good reason for inquiring whether this resemblance is not more than coincidence. There are no other horned forms in which the strepsicerine characters are developed, and the twisted-horned antelopes have been quite conspicuously represented in Tertiary time, their origin dating back at least to the Miocene period. Inasmuch as the antelope group has been presumed to be derived from forms near *Merycodus* it would not seem improbable that types like *I. schizoceras* should appear in the period of transition to the true strepsicerine forms, and possibly also in the young of early representatives of that group.

The resemblance of the horn-core of this form to that in *Antilocapra* consists largely in the general similarity of the surface structure. The form and position of the horn are not like those of the pronghorns, and the nature of the terminal region is also distinctly different. The fact that this horn-core is divided into two terminal prongs and that the outer or sheath portion of the horns of *Antilocapra* divides seems not to be a valid ground for comparison, as the horn-core in *Antilocapra* is not divided. That the horn-core of *Antilocapra* may have been divided originally, the anterior prong of the core afterward disappearing in that genus, is possible, but we have as yet no evidence to show that such has been the actual course of evolution of the horn. If any relationship is suggested by the divided tip it would seem most natural to associate the form of horn seen here with the simpler types of *Merycodus*.

Associated Remains of Skeleton and Dentition.—Associated with the peculiar horn no. 11893, there are many parts of the skeleton and dentition representing several small antelope-like individuals. Although these parts have not been obtained in such association as to indicate that they certainly belong to *Ilingoceros schizoceras*, and they may be found to represent several species or genera, by process of exclusion they suggest certain possibilities as to the character of this species and of other antelope-like forms of this region.

All of the fragments of *teeth* found associated with these remains

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[29] Merriam, J. C., *op. cit.*

represent hypsodont molars of about the same stage of advance as those of *Antilocapra*. The best preserved specimen in this collection is the outer wall of a third upper molar. The tooth is considerably smaller than in the specimens referred tentatively to *Sphenophalos*, and the outer styles are a little more prominent. The association of hypsodont molars of the *Antilocapra* type with the antelope-like remains from Thousand Creek has thus far been a rule without exception.

The *femur* is known by fragments representing the proximal and distal ends. The proximal portion of the articular surface of the head is elongated transversely about as in the pronghorn. The distal end does not differ essentially from that of the femur in the pronghorn.

The proximal end of the *tibia* differs from the pronghorn in the presence of a well-marked emargination in the overhanging border of the postero-internal portion of the proximal face. The proximal rudiment of the *fibula* is a little smaller than in the pronghorn specimen available for comparison. The distal end is not appreciably different from that of *Antilocapra*. The upwardly projecting spine has about the same relative dimensions as in *Antilocapra*.

The *calcaneum* is similar to that of *Antilocapra*. At the posterior end of the internal ridge of the trochlea of the *astragalus* there is a noticeable prominence which extends downward and slightly inward over the sustentacular portion of the calcaneum. The inner portion of the trochlea extends downward over this process instead of turning slightly forward beneath the astragalus as in *Antilocapra*.

In the *lunar* of the fossil form the hook which extends downward over the posterior side of the unciform is longer than in *Antilocapra*. Corresponding to this modification of the lunar there is a deep pit on the posterior side of the *unciform* immediately behind the face for contact with the lunar (figs. 75 and 77). The posterior hook of the lunar is received in this pit. In the unciform of *Antilocapra* there is only a shallow depression where the pit is situated in the fossil form, and the posterior portion of the articular face for the lunar is not continued downward as sharply as in the fossil form. The unciform also differs from that of *Antilocapra* in the development of a downwardly projecting process extending from the posterior side, immediately below the pit for the reception of the posterior hook of the lunar. In *Antilocapra* the posterior border is almost per-

fectly even in this region.   There is shown here a tendency to develop a more specialized interlocking joint in the wrist of the fossil form than is shown in *Antilocapra*.
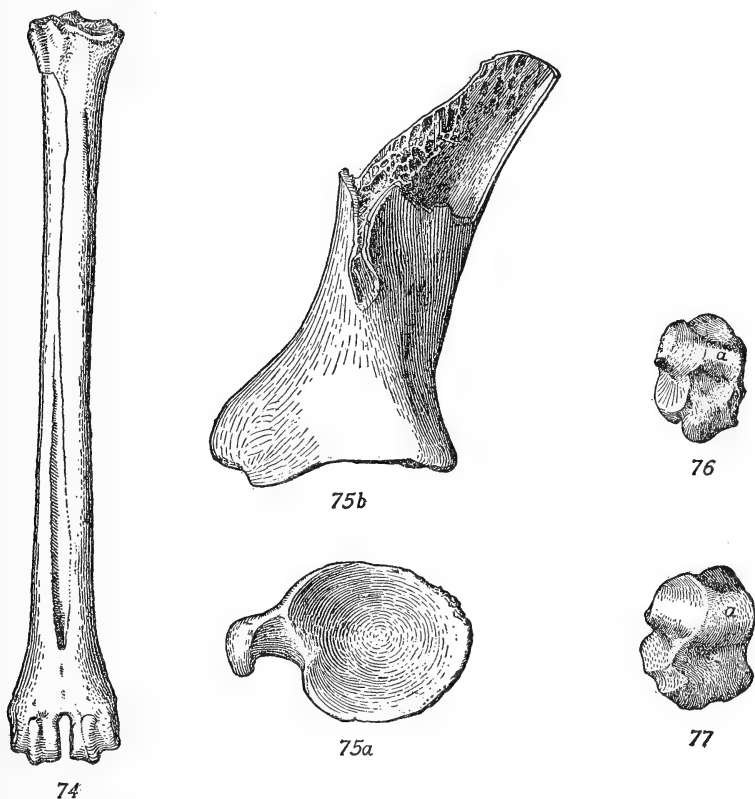
Fig. 74.   *Ilingoceros schizoceras*, n. sp.?   Posterior metapodial.   No. 19419, × ½.   Thousand Creek Beds, Thousand Creek, Nevada.

Figs. 75a and 75b.   *Ilingoceros schizoceras*, n. sp.   Proximal portion of scapula.   No. 11892, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.   Fig. 75a, outer view; fig. 75b, proximal view.

Fig. 76.   *Ilingoceros schizoceras*, n. sp.?   Superior side of unciform; *a*, articulation with lunar.   No. 19420, natural size.   Thousand Creek Beds, Thousand Creek, Nevada.

Fig. 77.   *Antilocapra americana* Ord.   Superior side of unciform; *a*, articulation with lunar. No. 8299, Calif. Mus. Vert. Zool.; natural size.

The metatarsals (fig. 74) are not essentially different from those of *Antilocapra*.   They vary considerably in size in different individuals.   This bone in no. 11892 is relatively a little narrower than in *Antilocapra*.

The terminal *phalanges* of the fossil forms differ from those of *Antilocapra* in that they are a little sharper, or more distinctly pointed anteriorly, and the inferior foramen on the inner side of the posterior end is on the average of approximately the same size as the postero-superior foramen on the inner side, instead of being much smaller as in *Antilocapra*.

In the proximal end of a *scapula* (figs. 75*a* and 75*b*) available there is a slight difference from *Antilocapra* in the form of the coracoid process. In *Antilocapra* the process is wider transversely and is not separated from the external border of the glenoid cavity by a shallow notch as in the fossil form.

The proximal end of the *radius* is a little more extended on the outer side just outside of the proximal articular surface in *Antilocapra* than in the fossil form.

A broken *vertebra* from the posterior cervical region (5th?) seems to have larger zygapophyses than in the corresponding vertebra of *Antilocapra*. In a middle dorsal vertebra the zygapophysial faces are also relatively large, and the centrum is relatively low. Several lumbar vertebrae present in the collections have longer and lower centra than in *Antilocapra*. In one of these the spinal nerve passed through a foramen situated several millimeters in advance of the posterior margin of the neural arch.

ILINGOCEROS or SPHENOPHALOS

Several fragmentary specimens representing the dentition of antelope-like forms from Thousand Creek resemble those referred to *Sphenophalos* in most respects, but are smaller and may belong with some of the forms referred to *Ilingoceros*.

A portion of the upper jaw, no. 12613 (figs. 68*a* and 68*b*), with P³ to M¹ represents an animal somewhat smaller than *Antilocapra* or than the teeth tentatively referred to *Sphenophalos nevadanus*. The teeth are apparently hypsodont, though considerably reduced by wear. M¹ is slightly narrower than in *Antilocapra* and the median rib on the outer side of the paracone is more prominent than in that form. P⁴ is considerably narrower and apparently a little less advanced in the development of the crescents. The form represented by this jaw evidently belongs to a species distinct from that in which the larger teeth referred to *Sphenophalos nevadanus* are included. It may correspond to a smaller species of *Sphenophalos*,

or may represent one of the species in the group of twisted-horned forms included in the genus *Ilingoceros*.

A smaller upper molar, no. 12605 (figs. 69*a* and 69*b*), and a lower molar, no. 12612, may be referred tentatively to the same group as the upper jaw fragment, no. 12613. They are both hypsodont, and resemble *Antilocapra* in most respects. The upper molar, no. 12605, is smaller anteroposteriorly and transversely than in *Antilocapra*, and possesses a minute style between the protocone and hypocone pillars. The lower molar, no. 12612, is shorter anteroposteriorly and considerably narrower than in *Antilocapra*. Both of these specimens evidently belong to a form related to that represented by the larger teeth included in the species referred to *Sphenophalos nevadanus*.

ILINGOCEROS ALEXANDRAE Merriam

Ilingoceros alexandrae Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 320, 1909. From the Thousand Creek Beds of Thousand Creek, Humboldt County, Nevada.

Affinities.—Since publishing the original description of this peculiar form, the collections from Thousand Creek have been carefully examined for material which might furnish additional information regarding its structure and affinities. Excepting such information as has been presented above under the discussion of *I. schizoceras*, nothing has appeared which suggests any modification of the original description. The only light which is thrown on the question of affinities of the genus *Ilingoceros* is developed through study of the other remains representing antelope forms obtained from the same formation. An examination of the remains associated with those of *Ilingoceros* in the formation at Thousand Creek does, however, offer certain suggestions which seem to demand consideration.

Thus far in the collections at Thousand Creek the specimens representing the dentition of antelope-like forms include only hypsodont molar teeth. No short-crowned teeth like those of *Tragelaphus* have been discovered. Also worthy of note is the general absence from the outer side of the lower molars of prominent styles or pillars such as appear between the columns of the short-crowned lower molars of *Tragelaphus* and *Strepsiceros*. In one or two specimens of

molars from Thousand Creek small intermediate styles are seen, but they are very poorly developed.

When the first studies of the antelopes of the Nevada Tertiaries were being carried on the writer was aware of the presence of several forms of large molar teeth of antelope-like forms in the collections from Virgin Valley and Thousand Creek, but was not at that time able to make certain as to the association of the horns and teeth. Since the publication of the first paper it has been shown that all of the large molar teeth with basal intermediate styles were obtained from exposures in Virgin Valley, which represent a much lower horizon than those of Thousand Creek from which all of the twisted-horned forms were derived. All of the larger Virgin Valley specimens representing antelope-like forms are to be referred to *Dromomeryx* (*Palaeomeryx*).

Some of the hypsodont molars from Thousand Creek presumably represent the forms included in the genus *Sphenophalos*, but one seems hardly justified in referring all of the specimens to that genus, inasmuch as not more than a third of the total number of skull fragments obtained belong to *Sphenophalos*, and in two instances horn-cores representing the twisted form were found in fairly close association with the long-crowned molars, while remains of *Sphenophalos* were absent.

It appears most reasonable to consider the probabilities in favor of associating some of the long-crowned molars with the skull fragments bearing twisted horns. Some of these teeth, as has been shown under the discussion of *Sphenophalos*, are evidently near the *Antilocapra* type, and none of them, so far as known, seem to differ greatly from those of that form. It is also true that such skeletal remains as are known seem to differ little in general character from the type of *Antilocapra*. Unfortunately, excepting the skulls, no skeletal parts of the tragelaphine antelopes are available to the writer for comparison with that group.

The indirect evidence of relationship suggested by the dentition indicates that the twisted-horned forms are related to *Sphenophalos* and, with that genus, to *Antilocapra*. The presumable relationship of *Sphenophalos* to *Antilocapra* has already been discussed. It seems, however, certain that *Ilingoceros* is generically quite distinct from *Sphenophalos* and, whatever the grade of relationship, *Ilingoceros* seems farther from *Antilocapra* than is *Sphenophalos*.
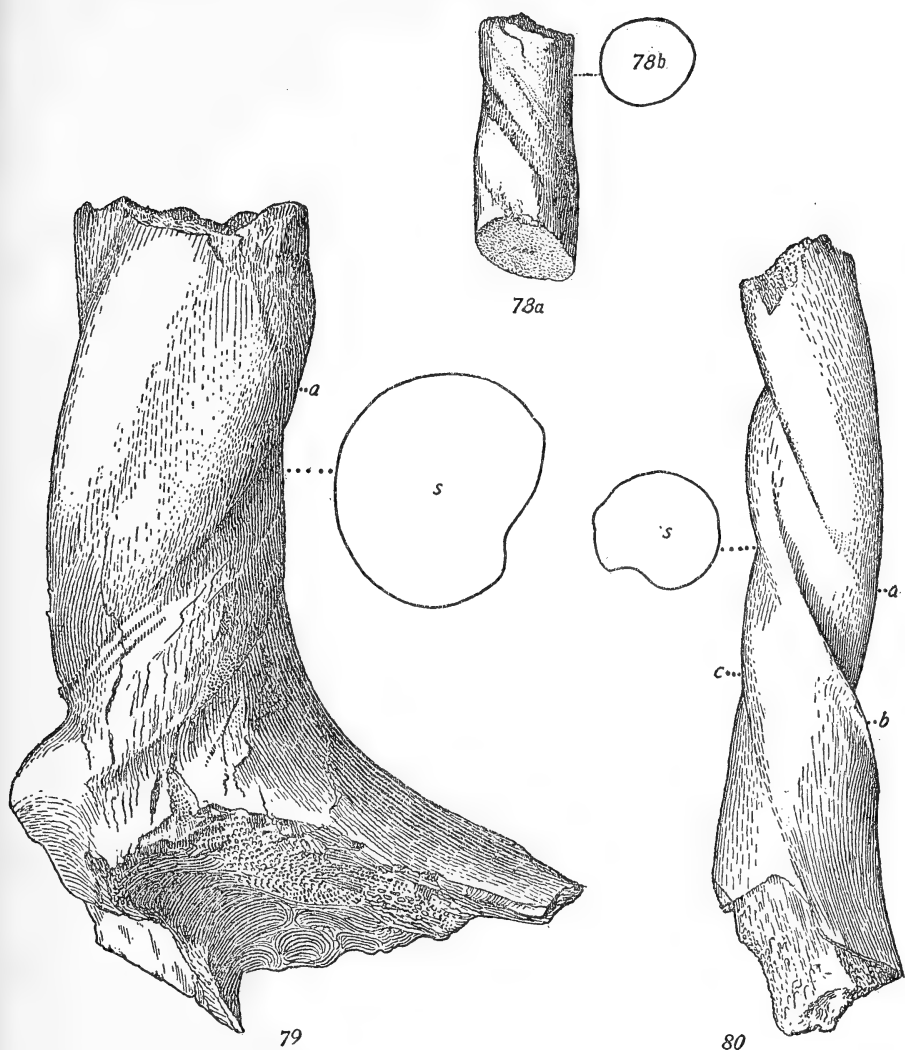
Figs. 78a and 78b. *Ilingoceros alexandrae* Merriam. Fragment from the distal region of horn. No. 11886, × ½. Thousand Creek Beds, Thousand Creek, Nevada. Fig. 78a, lateral view showing spiral; fig. 78b, cross-section of horn.

Fig. 79. *Ilingoceros alexandrae* Merriam. Posterior view of base of left horn-core; *a*, spiral ridge arising over the postero-superior region of the orbit; *s*, cross-section of horn-core. No. 11880, type specimen, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

Fig. 80. *Ilingoceros*, form B. Posterior to postero-median view of basal portion of right horn-core; *a*, anterior spiral ridge probably corresponding to ridge *a* in figure 79; *b*, median or lateral spiral ridge; *c*, posterior spiral ridge; *s*, cross-section of horn-core. No. 11892, natural size. Thousand Creek Beds, Thousand Creek, Nevada.

With the scanty evidence available, the characters in which *Ilingoceros* seems most distinctly connected with *Antilocapra* are the presumptive similarity in the dentition and the nature of the outer portion of the horn-core, which like that of *Sphenophalos* seems to be a little more dense than is common in the tragelaphine forms. Otherwise it is hard to find characters which are distinctively antilocaprine.

The discovery of the terminal portion of a twisted horn in the form described above as *Ilingoceros schizoceras* unexpectedly complicates the problem of the relationships of *Ilingoceros* through the addition of the character of terminal bifurcation to that of spiral twist. While it is by no means certain that the species referred to as *I. schizoceras* is generically identical with *I. alexandrae* the evidence suggests that the two are probably of common origin. The presence in *I. schizoceras* of a terminal bifurcation of the horn as in *Merycodus* lends some support to the theory that the Merycodontidae may be the ancestors of *Ilingoceros*.

In the present state of our knowledge there seem three hypotheses open to account for the presence of the twisted-horned antelopes in the Thousand Creek fauna: (1) They are typical Old World tragelaphines which came into America in late Miocene or early Pliocene time and developed long-crowned molar teeth. (2) They are tragelaphine forms which originated in America from Merycodus-like ancestors at some time during the Miocene, and soon migrated to the Old World, leaving only a few descendants here as late as the Thousand Creek epoch. (3) They are a peculiar twisted-horned division of the Antilocapridae originating in America and possibly limited to this continent.

On the whole, the writer is inclined to think that the evidence favors recognition of a fairly close relationship of *Ilingoceros* as well as *Sphenophalos* with the Antilocapridae, and that all of these forms may be derived from some member of the *Merycodus* group. With the evidence at hand, one does not seem justified in assuming that the Old World tragelaphines are necessarily derived from American Merycodus-like ancestors, though both may have come from the same stock. There seem to be some reasons for thinking that the older tragelaphines of the Old World may have been derived from some form like *Palaeomeryx* or *Dromomeryx* rather than from a Merycodus-like type. *Dromomeryx* of the American Miocene pos-

sesses antelope-like horns and a dentition which might have developed into the tooth type found in the more primitive of the true antelopes.

In addition to the evidence suggesting the presence in America of Old World types of antelopes as presented by the Thousand Creek fauna, Matthew and Cook[30] have recently described a peculiar antelopine or bovine horn-core, and an antelope-like dentition, from the late Tertiary beds of Snake Creek, Nebraska. As noted by Matthew and Cook, the dentition resembles that of the twisted-horned forms and not that of the type of antelope represented by the horn-core which has been provisionally associated with the dentition in their description. Inasmuch as the faunas of Thousand Creek and Snake Creek are not widely separated in time, one unavoidably considers the possibility that the teeth of the twisted-horned forms of the Thousand Creek fauna are not represented among the remains thus far collected at Thousand Creek, while at Snake Creek the teeth of these forms have been found without accompanying horns. Such an explanation seems, however, not to be within the limits of probability.

It would seem to the writer that with the evidence available we are not in a position to determine the affinities of the American twisted-horned antelopes with certainty. So far as can be determined they appear to be near the Antilocapridae, but they are evidently generically distinct from *Sphenophalos*. If, as seems probable, the only type of dentition known from the Thousand Creek Beds really represents this group along with *Sphenophalos*, these forms are probably derived with the Antilocapridae from some type like *Merycodus*, and are not closely related to the Old World strepsicerine forms. If teeth like those obtained by Matthew and Cook at Snake Creek belong to this group it may represent an immigration of typical Old World forms or might be derived from a Palaeomeryx-like American form.

With the available information it is probably desirable to refer *Ilingoceros* tentatively to a distinct family, the Ilingoceridae, and to include *Sphenophalos* in the Antilocapridae.

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[30] Matthew, W. D., and Cook, H. J., Bull. Am. Mus. Nat. Hist., vol. 26, pp. 413 and 414, 1909.

TRAGOCERAS(?) or ILINGOCEROS

In a former publication[31] the writer provisionally referred a fragment of a large horn-core from the Thousand Creek Beds to *Neotragocerus* of Matthew and Cook. This specimen consists of only a fragment representing the tip of a horn. In some respects it is quite similar to the tip of a *Tragoceras* horn. It may, however, represent the terminal portion of a large *Ilingoceros* horn on which the spiral has faded out before reaching the superior end. The surface structure is apparently less tragocerine than antilocaprine, though it is not easy to judge of this character in the terminal portion of the horn.

Transmitted February 15, 1911

[31] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 330, 1909.
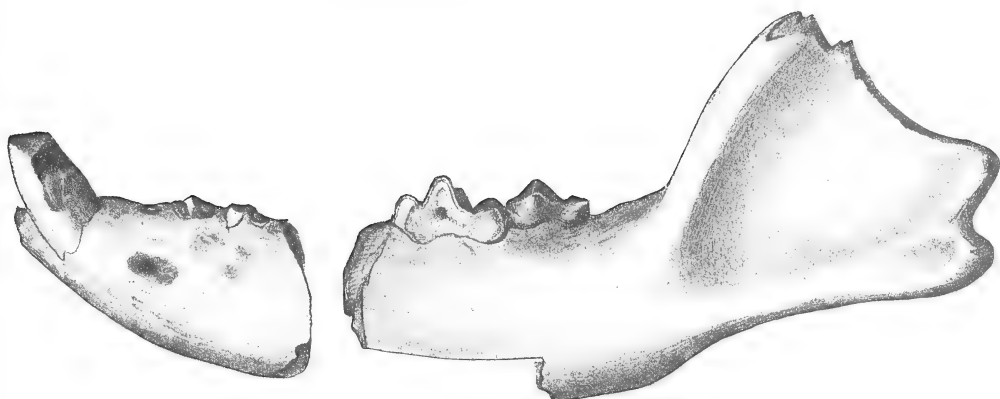
Tephrocyon kelloggi, n. sp.

FIG. 1. Right mandible. Type specimen, no. 11562, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

FIG. 2. Left mandible. Type specimen, no. 11562, natural size. Virgin Valley Beds, Virgin Valley, Nevada.

Maxillary of Mastodon (*Tetrabelodon?*, sp.) in place. Thousand Creek Beds, Thousand Creek, Nevada.

A FURTHER CONTRIBUTION TO THE MAMMALIAN FAUNA OF THE THOUSAND CREEK PLIO-CENE, NORTHWESTERN NEVADA

CONTENTS

INTRODUCTION

SINCE publication of the description and discussion of the Thousand Creek fauna in 1911,[1] further collecting in the Thousand Creek beds of northwestern Nevada by parties from the University of California has furnished additional palæontological materials on which the recognition of forms new to the fauna has been based and on which previously described species have become better known.

While the relationships of the fauna were discussed some years ago,[2] a description of the newly obtained material, with the exception of the badger remains described by Butterworth,[3] has never been published.

[1] J. C. Merriam, *Tertiary mammal beds of Virgin Valley and Thousand Creek in Northwestern Nevada, Pt. II: Vertebrate Faunas*, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 199–304, pls. 32–33, 1911.

[2] J. C. Merriam, *Relationships of Pliocene mammalian faunas from the Pacific Coast and Great Basin provinces of North America*, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, pp. 421–443, 1917.

[3] E. Butterworth, *A new mustelid from the Thousand Creek Pliocene of Nevada*, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, pp. 21–24, 1916.

The illustrations for this paper have been prepared by John L. Ridgway.

<center>DESCRIPTION OF MATERIAL</center>

<center>Ælurodon sp.</center>

Two mandibular fragments, No. 27248 U. C. C. (fig. 1), represent a large type of dog, presumably related to the genus *Ælurodon* and comparable in size to *Æ. wheelerianus*. In this specimen the jaw is heavy, although of smaller size than the *Ælurodon* jaws from the Ricardo which have been referred provisionally to *Æ. aphobus*.
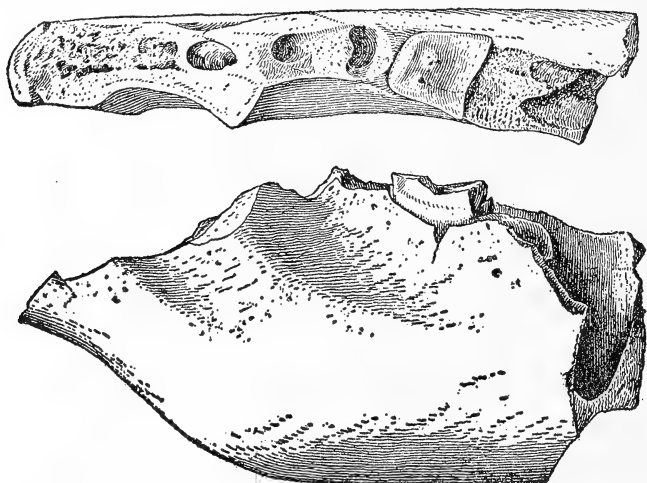
FIG. 1. *Ælurodon* sp. Mandibular fragment, No. 27248 U. C. Coll.; lateral and superior views, ×1.0. Thousand Creek Pliocene, Nevada.

Unfortunately all that remains of the lower dentition is the broken part of the heel of $\overline{M1}$. The heel region of this tooth narrows posteriorly as in *Æ. wheelerianus*.

<center>Pseudælurus? sp.</center>

An anterior portion of a ramus, No. 27247 U. C. C. (fig. 2), appears to belong to *Pseudælurus*. This specimen is distinctly smaller than the type of *P. intrepidus* Leidy. The roots of $\overline{P3}$ and $\overline{P4}$ remain in the jaw. In front of the anterior root of $\overline{P3}$ is a very small alveolus for a single-rooted tooth. The root of the canine is flattened transversely. Two mental foramina are present, one situated below the anterior root of $\overline{P3}$, the second below the posterior root of this tooth.

Pliohippus near fairbanksi Merriam

A number of cheek-teeth of horses of the *Pliohippus* type found in the Thousand Creek beds represent a form belonging in or near the group of *Pliohippus fairbanksi* or *P. supremus*.

Of the upper cheek-teeth unfortunately only fragmentary material has been secured, no complete teeth being known. The crowns of the upper cheek-teeth are strongly curved and well cemented. In the teeth available the fossettes are not of unusual width and the enamel border is comparatively little folded. The most important folds are those at the postero-internal angle of the anterior fossette. These folds taken with the type of the post-protoconal fold indicate that the nature of the union between protoloph and metaloph was
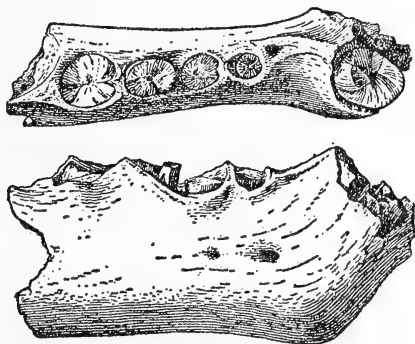
Fig. 2. *Pseudælurus?* sp. Mandibular fragment, No. 27247 U. C. Coll.; lateral and superior views, ×1.0. Thousand Creek Pliocene, Nevada.

much as in *P. fairbanksi*. The complete protocone is not known; so far as can be determined it was small and only slightly compressed laterally. So far as the characters of the upper cheek-teeth are concerned this species seems to belong nearer to the *P. fairbanksi* type as represented in the Ricardo and Rattlesnake forms than to any other species, unless it be *P. supremus*.

Pliohippus sp.

Several lower cheek-teeth from the Thousand Creek beds represent a *Pliohippus* of a type near *P. fairbanksi* of the Ricardo Pliocene. These teeth are long crowned and very heavily cemented. The outer walls of the protoconid and paraconid are convex. The metaconid-metastylid column is short anteroposteriorly and its inner gutter tends to be angular. Specimen 22423, including P$\bar{2}$ to

P$\overline{4}$ and an associated M$\overline{3}$ (fig. 3a, b), closely resembles No. 21346 from the Ricardo and No. 22388 from the Rattlesnake. The latter specimen has been referred to *Pliohippus spectans* (Cope). The M$\overline{3}$ associated with the premolars in the specimen from Thousand Creek also closely resembles the corresponding tooth of No. 22388 from the Rattlesnake.

A M$\overline{2}$ from another locality, No. 2745, shows some resemblance to that of a Ricardo species, No. 21789, referred to *P. tantalus*, but its
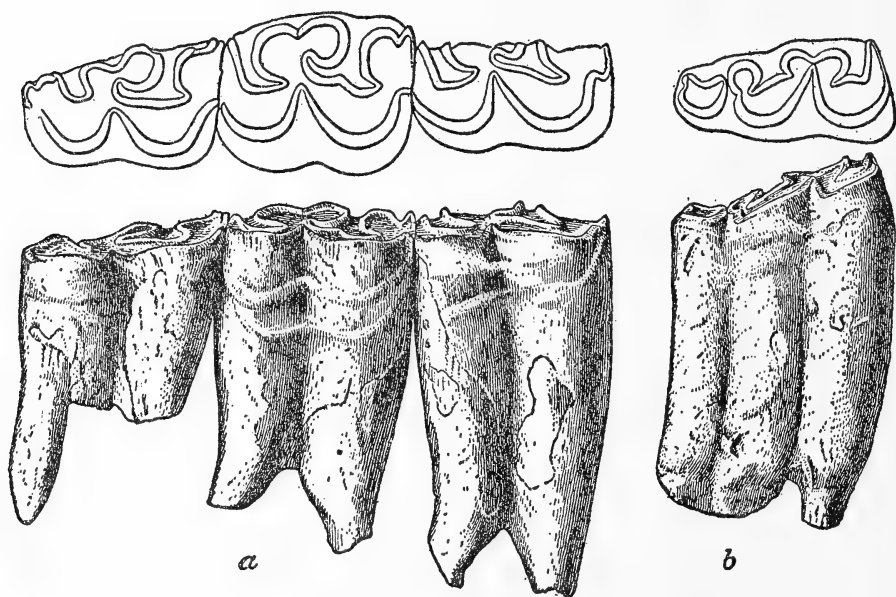
Fig. 3. *Pliohippus* sp. Lower cheek-teeth, No. 22423 U. C. Coll.; lateral and occlusal views, ×0.92. *a*, P$\overline{2}$ to P$\overline{4}$; *b*, M$\overline{3}$. Thousand Creek Pliocene, Nevada.

similarity to the *P. fairbanksi* form of the Rattlesnake might be as close if a specimen of corresponding stage of wear were available for comparison.

MEASUREMENTS (IN MILLIMETERS) OF No. 22423

P$\overline{2}$, anteroposterior diameter... 26.
P$\overline{2}$, greatest transverse diameter.. 16.
P$\overline{3}$, anteroposterior diameter... 26.1
P$\overline{3}$, greatest transverse diameter.. 18.3
P$\overline{4}$, anteroposterior diameter... 26.2
P$\overline{4}$, transverse diameter...
M$\overline{3}$, anteroposterior diameter... 30.
M$\overline{3}$, greatest transverse diameter.. 11.4

Hipparion (Neohipparion) leptode Merriam

A fragmentary skull and lower jaw of a *Hipparion*, No. 27126 U. C. Coll., found by Miss Annie M. Alexander and Miss Louise Kellogg in the Thousand Creek beds in 1920 give a nearly complete representation of the upper and lower dentition. Associated with this specimen and undoubtedly belonging to the same individual are the remains of its front feet.

In No. 27126 only a small portion of the lower orbital rim is preserved. Below and anterior to this border the crista facialis extends forward and is perhaps somewhat accentuated as a result of a little crushing to which the side of the face has been subjected. The crista descends and disappears above the anterior end of M$\underline{1}$. Malar and lachrymal fossæ are not defined. The surface of the maxillary anterior to P$\underline{2}$ and above the palatal border forms a deep concavity (fig. 4).

The palatal portion of the skull is likewise poorly preserved. The posterior palatine foramen lies opposite the anterior end of M$\underline{3}$. The maxillary tubercle is not large and separates a broad groove situated along its inner side from a short and narrow groove behind the last molar.

With the possible exception of *Hipparion mohavense* from the Ricardo, the dentition of no other *Hipparion* species of the Great Basin or California Tertiary is as completely known as that in the present specimen. A single upper incisor, I$\underline{2}$?, is shown in figure 4a. The upper canine (fig. 4c), is very small. The upper cheek-tooth series, P$\underline{2}$ to M$\underline{3}$, is completely preserved. P$\underline{1}$ is absent. The teeth (fig. 4) are well cemented. They are characterized by having large and considerably elongated protocones and rather complicated enamel folds bordering the fossettes. In the premolars the inner wall of the protocone tends to be flattened and the antero-external end is pointed and is directed outward and forward toward the inner wall of the protoconule. The anteroposterior diameter of the protocone is more than twice as great as the transverse diameter. The hypocone is small. The pli caballin projects inward and slightly forward in M$\underline{3}$, directly inward in M$\underline{2}$ and M$\underline{1}$, and inward and backward in P$\underline{4}$. In P$\underline{3}$ and in P$\underline{2}$ this structure is broadened and shows evidence of division. Although the enamel borders of the fossettes show numerous plications, particularly the posterior border of the pre-fossette and the anterior border of the post-fossette, the pattern is not as complex as that in *Hipparion mohavense*.
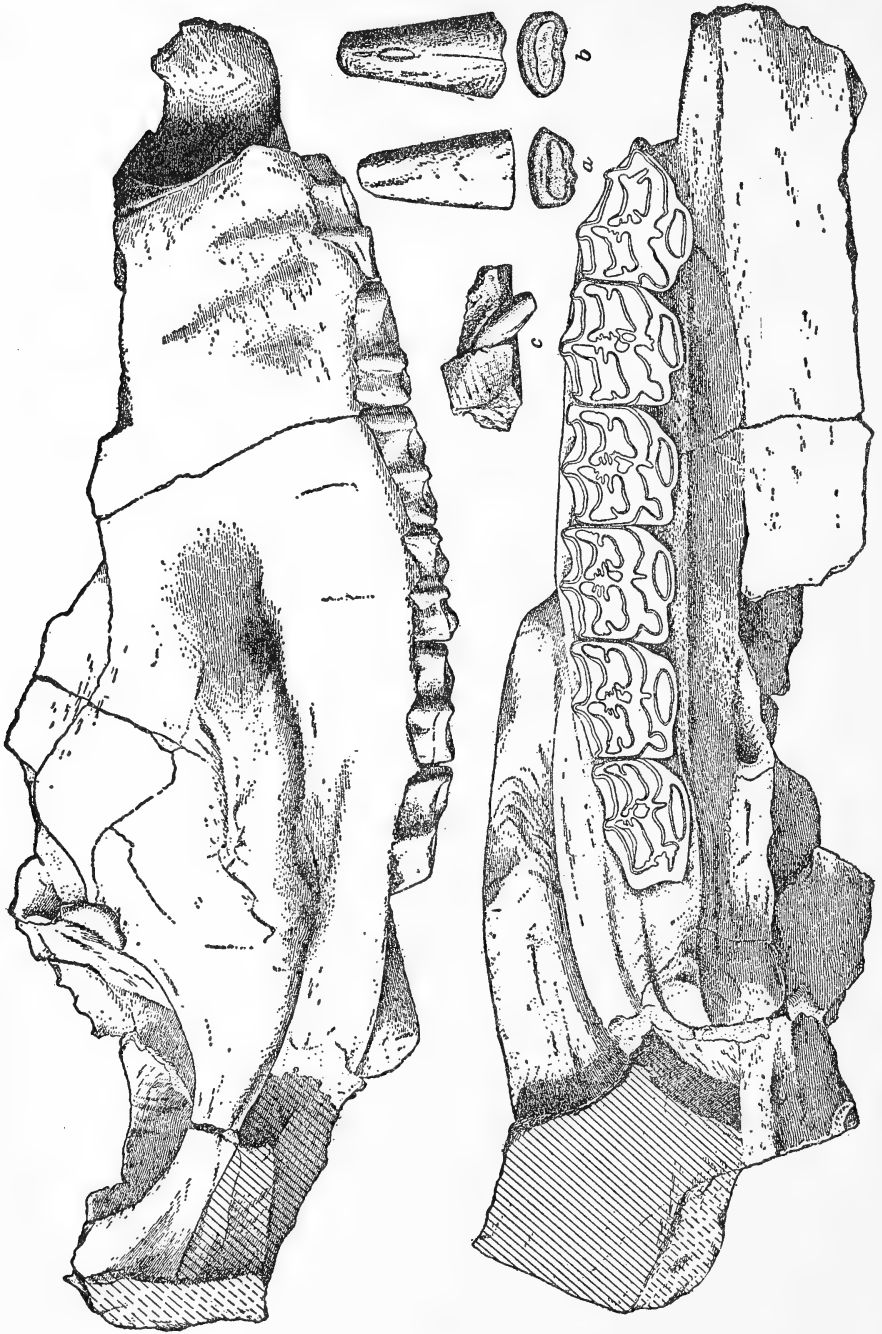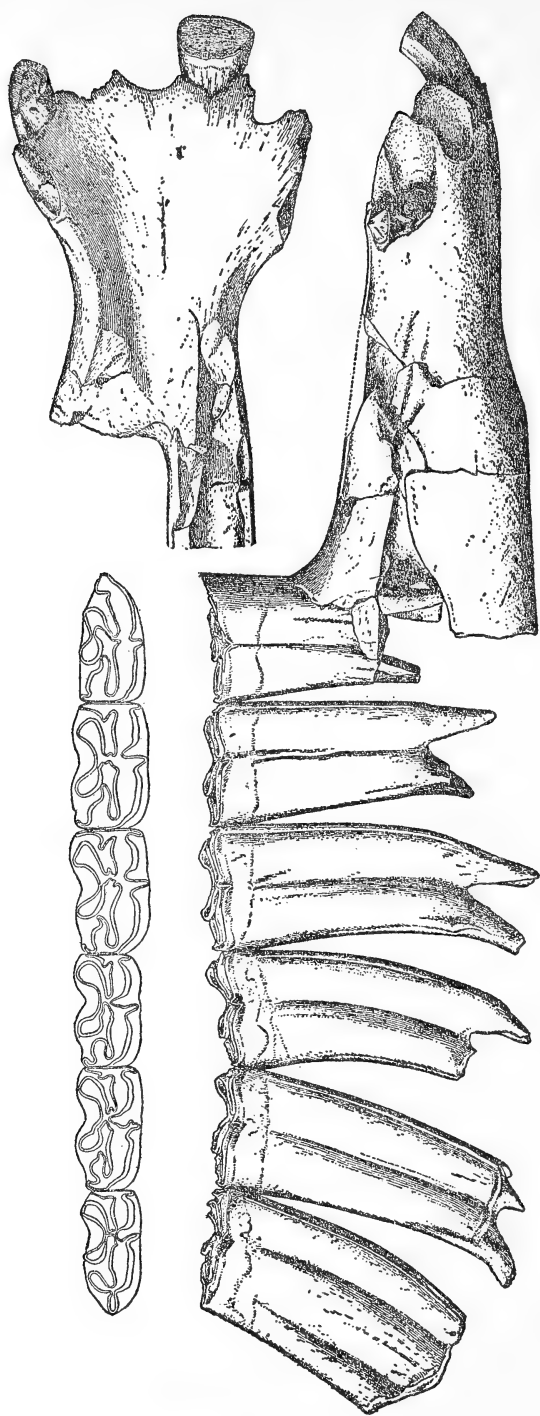
Fig. 4. *Hipparion (Neohipparion) leptode* Merriam. Skull fragment and superior dentition, No. 27126 U. C. C.; lateral and inferior views, ×0.66. *a* and *b*, superior incisors; *c*, superior canine. Thousand Creek Pliocene, Nevada.

In the fragmentary upper tooth,[4] No. 12581 U. C. C., found at the same locality with the type of *Hipparion leptode*, the fossettes are quite narrow, but this character may not be emphasized more strongly in No. 12581 than in teeth of No. 27126.

The lower dentition and the anterior portion of the lower jaw are shown in figure 5. The incisors that are preserved have large pits with heavy deposits of cement. The lower canine is very small. The lower cheek-teeth are narrow and also heavily cemented. The metaconid-metastylid column is long anteroposteriorly, with a broad longitudinal furrow in the posterior premolars and in the molars. This groove deepens in the premolar series from $P\overline{2}$ to $P\overline{4}$ and remains deep in the molar teeth. The furrow is distinctly deeper and wider than in lower teeth of *Hipparion mohavense*. In the premolars the entoconid is long anteroposteriorly and its anterior end is pointed. In all the cheek-teeth, with the exception of $M\overline{3}$, the hypoconulid (of Osborn) projects distinctly beyond the inner wall of the entoconid. The outer walls of protoconid and hypoconid tend to be flattened. A small fold is present at the antero-external angle of the tooth except in $P\overline{2}$. In addition to this fold a strong external ridge at the anterior end of the hypoconid is present. This ridge is particularly prominent in $P\overline{4}$. In the premolars it projects directly outward, in the posterior molars outward and slightly forward.

Relationship of No. 27126—In both the type of *H. leptode*, No. 19414 U. C. C., and No. 27126 the lower tooth-crown is narrow and slender, with the metaconid-metastylid column and inner furrow revealing similar characters. In both specimens, also, a strong external ridge is present on the hypoconid as well as at the anterior end of the protoconid. There appears little reason for doubting, therefore, the specific identity of the two forms. The lower tooth described by Merriam[5] as the type of this species was regarded as representing $M\overline{2}$. A comparison of the tooth with the complete set of molar teeth in No. 27126 indicates that No. 19414 resembles $M\overline{3}$ rather than $M\overline{2}$ in certain of its characters, as for example in narrowness of the tooth-crown, in posterior elongation of the hypoconulid, and in, perhaps, the attitude of the external ridge of the hypoconid. It appears quite possible, therefore, that the type of *H. leptode* is a third lower molar.

[4] J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 263, figs. 32a, 32b, 1911.

[5] J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 9, pp. 3–5, fig. 3, 1915.

Fig. 5. *Hipparion (Neohipparion) leptode* Merriam. Mandibular fragment and lower dentition, No. 27126 U. C. C.; lateral and superior views, ×0.66. Thousand Creek Pliocene, Nevada.

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The *Hipparion* species of the Ricardo horizon have uniformly smaller and less elongated protocones. The nearest approach among the Great Basin hipparions is in the Rattlesnake Pliocene forms, among which compressed and elongated protocones predominate. *H. sinclairii* of the Rattlesnake may have a large and strongly compressed protocone, but teeth referred to this species may be smaller than No. 27126. Several specimens from the Rattlesnake fauna referred to *H. occidentale* have dimensions comparable to those of No. 27126 and show compression of protocone combined with complication of enamel folds. Among these specimens are lower teeth that clearly bear a close resemblance to comparable teeth in *H. leptode*. It seems not improbable that *Hipparion leptode, H. sinclairii* and *H. occidentale* represent a group of very closely related species.

MEASUREMENTS (IN MILLIMETERS) OF DENTITION, No. 27126

I1, greatest transverse diameter	15.4
I2?, greatest transverse diameter	16.6
C, greatest anteroposterior diameter	4.7
P2, anteroposterior diameter	27.1
P2, greatest transverse diameter	20.7
P3, anteroposterior diameter	24.2
P3, greatest transverse diameter	23.1
P4, anteroposterior diameter	22.8
P4, greatest transverse diameter	22.5
M1, anteroposterior diameter	23.
M1, greatest transverse diameter	22.6
M2, anteroposterior diameter	22.3
M2, greatest transverse diameter	21.
M3, anteroposterior diameter	22.7
M3, transverse diameter	117.3
Length of upper cheek-tooth series, P2 to M3	41.
Iī, transverse diameter	14.3
Iȝ, greatest diameter	12.1
C̄, anteroposterior diameter	4.1
P2̄, anteroposterior diameter	24.8
P2̄, greatest transverse diameter	13.
P3̄, anteroposterior diameter	23.8
P3̄, greatest transverse diameter	14.5
P4̄, anteroposterior diameter	23.7
P4̄, greatest transverse diameter	14.4
M1̄, anteroposterior diameter	22.8
M1̄, greatest transverse diameter	13.
M2̄, anteroposterior diameter	24.2
M2̄, greatest transverse diameter	12.6
M3̄, anteroposterior diameter	25.
M3̄, greatest transverse diameter	10.4
Length of lower cheek-tooth series, P2̄ to M3̄	144.3

Associated with the skull and lower jaw of No. 27126 are the remains of the two front feet.   An incomplete specimen representing the right front foot of *Hipparion leptode* is shown in Plate I, figures 1 and 2.   Unfortunately metacarpals II and III are not entirely preserved, but the fragments which remain indicate conclusively that the elements flanking metacarpal III were completely formed and carried side toes.   One of the lateral digits occurs in the collection.   It is shown in Plate I, figure 4, as representing the fourth digit of the right front foot.[6]
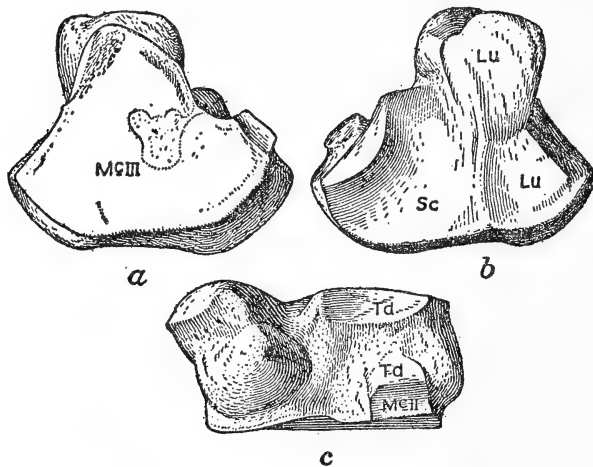
Fig. 6. *Hipparion* (*Neohipparion*) *leptode* Merriam.   Left magnum, No. 27126 U. C. C.; ×1.0.   *a*, distal view; *b*, proximal view; *c*, inner view, showing facets McIII for metacarpal III, Sc, for scaphoid, Lu, for lunar, Td, for trapezoid, and McII for metacarpal II.   Thousand Creek Pliocene, Nevada.

The carpus includes the magnum, lunar, pisiform and cuneiform. In the magnum (fig. 6*a*, *b*, *c*) the anterior portion of the articulating surface for the scaphoid is relatively broad anteroposteriorly.   The posterior end of the lunar facet does not bend downward as much as in *Equus*.   The opposite surface for the metapodial, as shown in figure 6*c* has a somewhat different shape from that in *Equus*.   The upper anterior facet for the trapezoid is noticeably concave in its longest diameter.   No posterior facet for the trapezoid is present. In anterior view the lunar is seen to be slightly less wedge-shaped

[6] The possibility that the digit is the second of the left front foot does not appear, however, to be entirely eliminated.

than in *Equus*, and the element is less constricted through its middle than in the latter genus.   The facet for the unciform is relatively broader than in *Equus*.   The posterior knob or process above the facet for the magnum is less prominently developed in the Pliocene form than in *Equus*.   The cuneiform and pisiform are shown in figure 8.
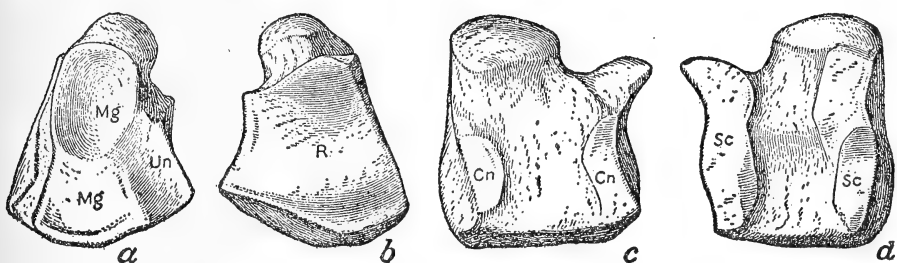
Fig. 7. *Hipparion (Neohipparion) leptode* Merriam.   Right lunar, No. 27126 U. C. C.; ×1.0.   *a*, distal view; *b*, proximal view; *c*, outer view; *d*, inner view, showing facets Mg, for magnum, Un, for unciform, R, for radius, Cn, for cuneiform, and Sc, for scaphoid.   Thousand Creek Pliocene, Nevada.
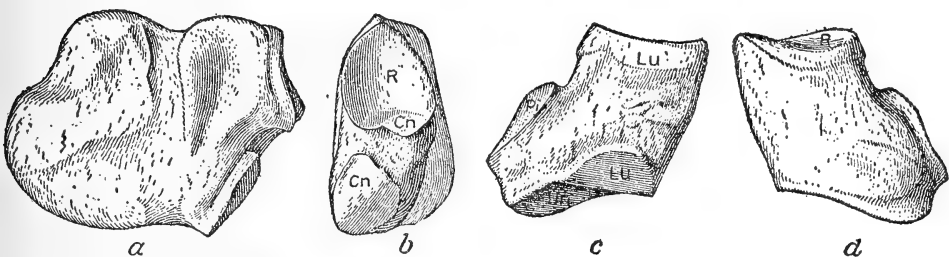
Fig. 8. *Hipparion (Neohipparion) leptode* Merriam.   *a* and *b*, right pisiform, views of outer side and articulating end showing facets R, for radius, *Cn*, for cuneiform.   *c* and *d*, left cuneiform, outer and inner views showing facets Lu, for lunar, Un, for unciform, and Pi, for pisiform; ×1.0.   No. 27126 U. C. C.   Thousand Creek Pliocene, Nevada.

Metacarpal III is a slightly longer but decidedly stouter element than that of *Hipparion whitneyi*.   At the proximal end the plane of the unciform surface makes an angle of 46° with that of the magnum facet.   The shaft increases slightly in width downward from the end of the proximal fourth.   In broadness of shaft this element differs somewhat from that in *H. whitneyi*.   On the posterior face of the distal articulating surface the lower limits of contact between this surface and the sesamoid bones are plainly marked.   The median keel in this region is sharp, while in front it becomes rounded.

The side elements, metacarpals II and IV, are completely developed although not entirely preserved in No. 27126. In *H. whitneyi* the shaft of the lateral metapodials becomes of splint-like proportions in the lower three-quarters of its total length, although the lower end expands and supports a lateral digit. In *H. leptode* the shaft of the lateral metapodials is more strongly developed, thus reflecting in this respect also the greater robustness of the foot as contrasted with that of the Great Plains species. While no facet is recognized at the proximal end of metacarpal II in No. 27126 suggesting the presence of a rudiment of metacarpal I, a relatively large facet is present on the fourth metapodial for a rudimentary fifth element.
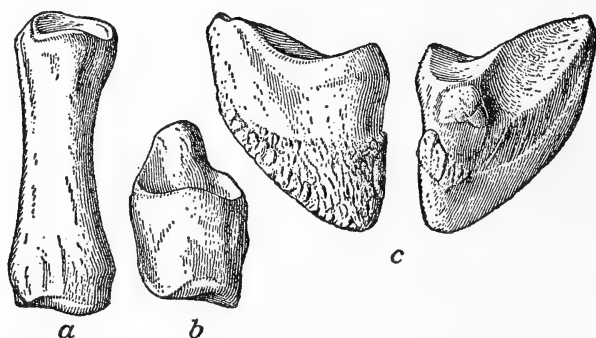
FIG. 9. *Hipparion* (*Neohipparion*) *leptode* Merriam. Lateral digit of manus, No. 27126 U. C. C.; ×1.0. *a*, phalanx I, superior view; *b*, phalanx II, superior view; *c*, phalanx III, superior and inferior views. Thousand Creek Pliocene, Nevada.

The single lateral digit consisting of three phalanges present in the collection has essentially the characters seen in *H. whitneyi*. The individual elements are distinctly larger than in the latter species. In phalanx II the outer half of the posterior lower margin is drawn backward to form the border of a distinct process. In phalanx III the outer portion of the segment is carried backward to form a thin plate of bone lying below and in back of the proximal articulating surface. Beneath the proximal articulation the ventral surface is perforated by several vascular foramina. The anterior portion of this surface is convex transversely. The superior surface is decidedly rugose along the anterior border.

Excepting size, the phalanges of the median digit again show resemblance to the comparable elements in *H. whitneyi*. The apex

of phalanx III is cleft, although relatively not as deeply as in the latter form.

MEASUREMENTS (IN MILLIMETERS) OF FOOT ELEMENTS, No. 27126

Carpals—
Magnum, greatest transverse diameter.................................. 35.3
Magnum, greatest anteroposterior diameter............................ 30.8
Magnum, greatest dorso-ventral diameter.............................. 18.9
Lunar, greatest transverse diameter.................................... 24.
Lunar, greatest anteroposterior diameter.............................. 27.8
Lunar, greatest dorso-ventral diameter................................ 25.8
Cuneiform, dorso-ventral diameter..................................... 21.7
Pisiform, greatest length through middle.............................. 38.7

Metacarpal II—
Greatest diameter of proximal end.................................... 17.8
Greatest diameter of distal articulating end.......................... 18.2
Transverse diameter of distal articulation............................ 9.3

Metacarpal III—
Greatest length... 228.2
Width of proximal end.. 38.5
Anteroposterior diameter of proximal end............................. 28.2
Transverse diameter at middle of shaft............................... 25.9
Anteroposterior diameter at middle of shaft.......................... 21.5
Transverse diameter of distal end.................................... 34.7
Anteroposterior diameter through median keel........................ 29.6

Metacarpal IV—
Greatest diameter of proximal end.................................... 18.

Lateral digit—
Phalanx I, greatest length.. 39.1
Phalanx I, greatest transverse diameter of proximal end............... 13.
Phalanx I, greatest dorso-ventral diameter of proximal end............ 18.2
Phalanx I, greatest transverse diameter of distal end................. 13.
Phalanx II, greatest length through middle........................... 15.7
Phalanx II, greatest width... 14.8
Phalanx III, greatest width.. 21.2
Phalanx III, dorso-ventral diameter.................................. 15.5
Phalanx III, length.. 30.5

Digit III—
Phalanx I, greatest length... 67.
Phalanx I, greatest depth of proximal end............................ 29.3
Phalanx I, greatest width of proximal end............................ 38.
Phalanx II, greatest length.. 38.7
Phalanx II, width of proximal end.................................... 37.4
Phalanx III, greatest length... 60.8
Phalanx III, greatest width.. 56.7
Phalanx III, greatest dorso-ventral diameter......................... 34.

Hipparion leptode Merriam or H. occidentale Leidy?

A single upper cheek-tooth, No. 22380 (fig. 10), represents a *Hipparion* form similar in size to No. 27126. The occlusal surface exhibits a large and elongated protocone and the enamel borders of the fossettes show slightly more complicated folds than in No. 27126. A short spur of enamel suggests a pli caballin. While the
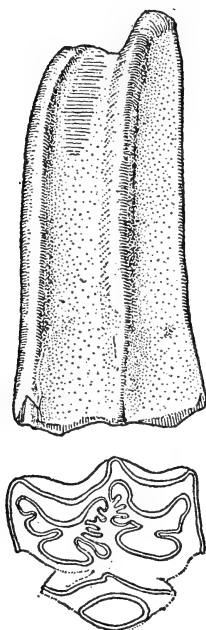
FIG. 10. *Hipparion leptode* Merriam or *H. occidentale* Leidy?. Upper cheek-tooth, No. 22380 U. C. C.; lateral and occlusal views, ×1.0. Thousand Creek Pliocene, Nevada.

protocone is comparable in length to that in teeth of No. 27126, it is noticeably wider transversely than in the latter specimen.

No. 22380 may represent *H. leptode* or may be referred provisionally to *H. occidentale*.

MEASUREMENTS (IN MILLIMETERS) OF No. 22380

Anteroposterior diameter... 24.3
Transverse diameter.. 22.3
Anteroposterior diameter of protocone................................. 9.8

Teleoceras fossiger (Cope)

Rhinocerotid remains are abundantly represented in the collections from Thousand Creek, but the material usually represents fragmentary and incomplete parts of the skeleton.

A fragmentary skull and lower jaw with dentition, No. 22901, furnishes perhaps the most satisfactory evidence on which determination of the Thousand Creek type can be based. Unfortunately only a small portion of the face and a part of the zygomatic arch
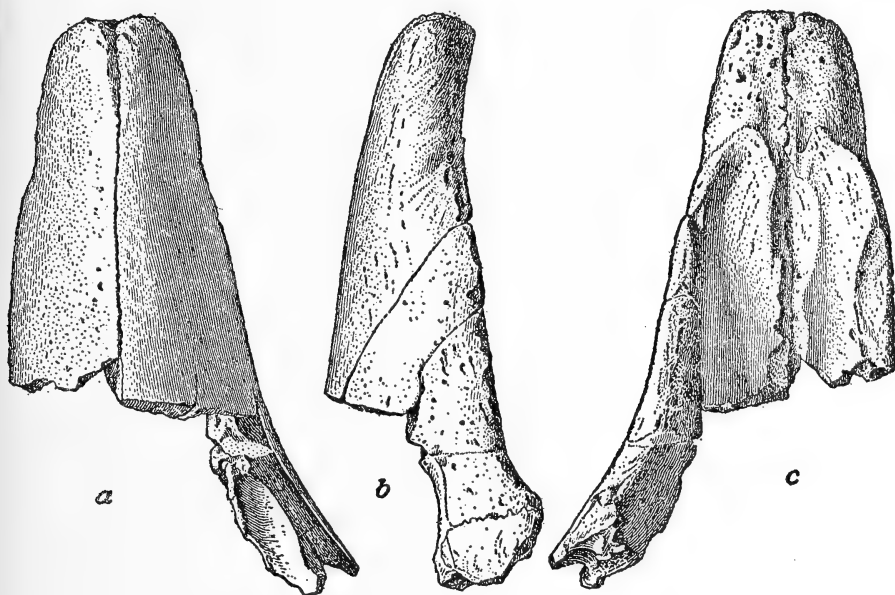
FIG. 11. *Teleoceras fossiger* (Cope). Nasals, No. 22901 U. C. C.; ×0.50. *a*, superior, *b*, lateral, *c*, inferior view. Thousand Creek Pliocene, Nevada.

remain in the skull of this form (Plate 2), but the cheek-teeth are fairly well preserved. The jugal is heavy and deepens posteriorly. The antorbital foramen is situated at a relatively short distance in front of the maxillo-jugal suture and lies above the anterior end of P3. The nasals, shown in figure 11*a*, *b*, *c*, are slender and narrow anteriorly. While similar in character to those of *Teleoceras* described by Matthew,[7] the nasals in the Thousand Creek form do not possess a distinctly rugose upper surface of the anterior end.

[7] W. D. Matthew, Bull. Amer. Mus. Nat. Hist., vol. 38, p. 202, fig. 9c, 1919.

The upper dentition in No. 22901 consists of P$\underline{2}$ to M$\underline{3}$. The molar series is noticeably longer than the premolar series. In the premolars and in the first molar the pre- and postfossettes are closed and the prefossette is distinctly larger than the postfossette. In M$\underline{2}$ well-developed crochet and antecrochet are present, but the crista seems to be absent.

Only the anterior portion of the lower jaw is present, but the lower dentition is well preserved (see plate 3). The symphysis reaches back to a point opposite the middle of P$\overline{4}$. A mental foramen is situated close to the inferior border and below the middle of P$\overline{4}$. The diastema between the incisor tusk and the anterior premolar is very short and the side of the jaw in this region is deeply concave. The distance between the tusks is also very short. Very small, shallow depressions are present on the anterior border of the symphysis.

The lower tusk is large and sweeps upward in a decided curve, the tip reaching a point well above the level of the tooth-row. The worn surface of this tooth is well shown in Plate 3. The lower cheek teeth include P$\overline{3}$ to M$\overline{3}$, with a remnant of a root representing probably a rudimentary P$\overline{2}$.

A number of foot-bones in the collections from Thousand Creek belong without much doubt to the short-footed *Teleoceras*. The metapodials exhibit characters very close to those seen in comparable elements of the Great Plains species.

The rhinocerotid types of the Ricardo deposits, Mohave Desert, California, are clearly distinguishable from the Thousand Creek genus. These forms have been described as belonging to *Aphelops* and to *Peraceras?* The lower jaw from the Ricardo which has been provisionally referred to *Peraceras*[8] differs decidedly from *Teleoceras* in the greatly shortened symphyseal region and in the absence of a lower tusk. The presence of these forms in the Ricardo fauna and the absence of *Teleoceras* may be taken as a further indication of the faunal difference which exists between the Ricardo and Thousand Creek horizons.

It appears quite possible that several distinct rhinocerotid genera occur in the Rattlesnake fauna. Metapodials of short-footed forms

[8] C. Stock and E. L. Furlong, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 16, pp. 50–51, pl. 10, 1926.

having considerable resemblance to those of *Teleoceras fossiger* are known from the Rattlesnake deposits.

MEASUREMENTS (IN MILLIMETERS) OF DENTITION, No. 22901

P2, anteroposterior diameter	30.9
P2, transverse diameter	35.
P4, anteroposterior diameter	47.2
P4, transverse diameter	64.3
M1, anteroposterior diameter	51.9
M1, transverse diameter	65.4
Length from anterior end of P2 to posterior end of M1	146.3
Lower tusk, greatest anteroposterior diameter at base of worn surface	28.4
Lower tusk, greatest transverse diameter at base of worn surface	56.4
P3, anteroposterior diameter	a34.
P3, transverse diameter	28.2
P4, anteroposterior diameter	40.9
P4, transverse diameter	29.3
M1, anteroposterior diameter	42.6
M1, transverse diameter	a29.2
M2, anteroposterior diameter	a48.6
M2, transverse diameter	....
M3, anteroposterior diameter	52.
M3, transverse diameter	30.
Length from anterior end of P3 to posterior end of M3	a214.

In measuring the individual cheek-teeth the greatest diameters have been taken. *a*, approximate.

Prosthennops sp.

Little additional peccary material has been obtained since the original description of the fragments of the dentition from the Thousand Creek beds.[9]

Three premolar teeth and a portion of the maxillary, No. 30040 Mus. Pale. Univ. Calif. Coll., are shown in figure 12. The specimens were found at Locality 2744 U. C. Mus. Pale. The teeth represent P2 and P3 of the right side and P4 of the left.

P2 is a relatively large tooth, rudely triangular in shape. Two cusps are present on the outer side of the crown and are separated by a cleft which extends outward, backward and upward. An inner posterior cusp or incipient cusp is also present and a cingulum extends along the inner side. In the presence of three cusps, this tooth is apparently like that of *Prosthennops serus* (Cope) from the Upper Snake Creek. In possessing a greater number of cusps P2

[9] J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 272–275, figs. 52 to 53a, b, c, 1911.

differs from No. 11876 U. C. C., a tooth described from the Thousand Creek beds by Merriam[10] and provisionally regarded as P2.

P3 has three principal cusps of which the inner anterior one is the largest. The outer anterior cusp is larger than the outer posterior cusp. A cuspule of minor size lies in the region to the inner side of the outer posterior cusp and behind the inner anterior cusp. The posterior cingulum is well developed. P3 resembles in shape, and in a measure also in the arrangement of the tubercles the tooth, No. 11876, provisionally regarded by Merriam[11] as P3 of *Prosthennops* from the Thousand Creek.
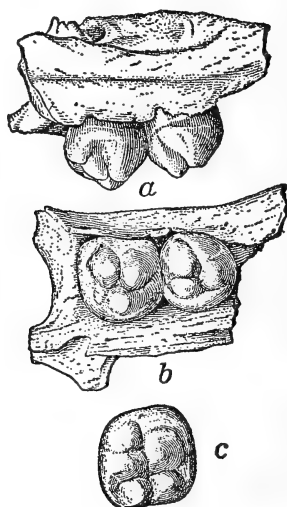
Fig. 12. *Prosthennops* sp. Maxillary fragment with P2, P3, and P4, No. 30040 U. C. C.; ×1.0. *a*, lateral view, *b*, occlusal view, *c*, occlusal view of P4. Thousand Creek Pliocene, Nevada.

In *P. serus* from the Snake Creek, P3, according to Matthew, has four main cusps.

The crown of P4 (fig. 12*c*), accompanying the maxillary fragment at Locality 2744 represents the tooth of the left side. This tooth is quadrate in shape and possesses an anterior transverse row of two cusps and a posterior transverse row of three cusps. The increase to three cusps in the posterior row is due apparently to a division of the inner posterior cusp into two parts. A cingulum is present

[10] J. C. Merriam, *op. cit.*, fig. 53*a*, p. 273, 1911.
[11] J. C. Merriam, *op. cit.*, fig. 53*b*, p. 273, 1911.

at the antero-internal corner and likewise at the postero-external corner of the tooth.

The maxillary fragment in No. 30040 U. C. C. includes small portions of the palate and face. The palatal portion is traversed by a canal. The facial portion exhibits the furrow or depression leading to the infraorbital foramen. In this depression and at a point above the anterior end of P$\underline{3}$ is the opening of a nutrient canal leading into the root region of the anterior premolars.

MEASUREMENTS (IN MILLIMETERS) OF No. 30040 U. C. C.

P$\underline{2}$, greatest anteroposterior diameter	9.3
P$\underline{2}$, greatest transverse diameter	10.
P$\underline{3}$, greatest anteroposterior diameter	10.9
P$\underline{3}$, greatest transverse diameter	11.1
P$\underline{4}$, greatest anteroposterior diameter	12.2
P$\underline{4}$, greatest transverse diameter	12.5

Sphenophalos nevadanus Merriam

Several specimens representing the bases of horn-cores of *Sphenophalos nevadanus* illustrate the typical characters of this species. Among these No. 22427 illustrates better than any specimen found up to this time the spreading type of horn with wedge-shaped cross-section, described in an earlier publication.[12] Unfortunately none of the known horn-cores show the summit. Nearly all of the specimens are broken off in much the same way and at nearly the same point, which suggests that there may have been a zone of weakness in this region, or that the bone above this point was of a somewhat different nature.

A small specimen, No. 22429 (fig. 13), less than half the size of the typical adult *Sphenophalos nevadanus*, shows a horn-core with a transversely flattened cross-section and a slight upward flare. At a distance above the base, somewhat less than twice the greatest width of this horn-core, the upper region is noticeably constricted by an outer or lateral longitudinal groove beginning near the base of the horn and by a faint concavity of the upper end of the median side. The cross-section of the horn at this point is dumb-bell-like and the contour of the surface suggests a division into two terminal spikes or points of approximately equal size at a short distance above this section. There is a slight element of twist in this specimen which

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[12] J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 326, 1909; *ibid*, vol. 6, p. 286, 1911.

bends the anterior portion of the horn-core laterally or outward as in *Sphenophalos nevadanus*.

A third specimen, No. 22430 (fig. 14), represents a still younger animal with horn-core not more than half the size of that in No. 22429. In the smallest specimen the complete, strongly compressed, band-like horn-core has a length not more than one and one-half times its greatest width and terminates in two approximately equal
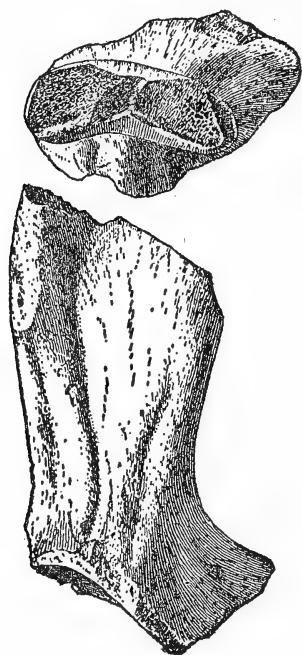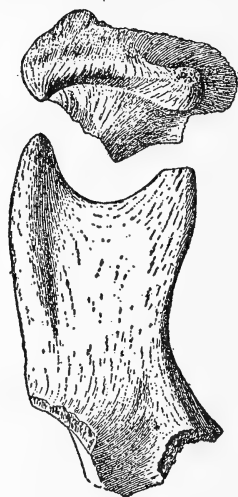
<div align="center">Fig. 13   Fig. 14</div>

Figs. 13 and 14. *Sphenophalos nevadanus* Merriam. Horn-cores; ×1.0. Fig. 13, No. 22429 U. C. C.; fig. 14, No. 22430 U. C. C. Thousand Creek Pliocene, Nevada.

points or spikes. The horn-core is slightly twisted and apparently the anterior spike is twisted outward.

While the available material is insufficient to furnish full proof, it is certainly strongly suggested that the smaller specimens, Nos. 22430 and 22429, show a transition series illustrating the origin of the horn-core in *Sphenophalos nevadanus*. The smallest specimen may represent a young individual of *S. nevadanus* or might be a distinct but smaller species. It is not improbable that complete

horns of *S. nevadanus* will be found comparatively short and may terminate in two small spikes.

Although the characters of *Sphenophalos* seem still quite distinct from those of *Ilingoceros* and the smallest horn-core, No. 22430, with complete, bifurcated tip is presumably nearest to *Sphenophalos*, this horn-core offers a suggestion as to origin of a previously described,[13] bizarre horn-core (No. 11893) with bifurcated tip and spirally twisted shaft. This peculiar specimen has been referred to *Ilingoceros* on account of its spiral shaft. The divided tip is possibly a heritage from a common ancestor of both *Sphenophalos* and *Ilingoceros*.

[13] J. C. Merriam, Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 293, figs. 73*a*, 73*b*, 1911.
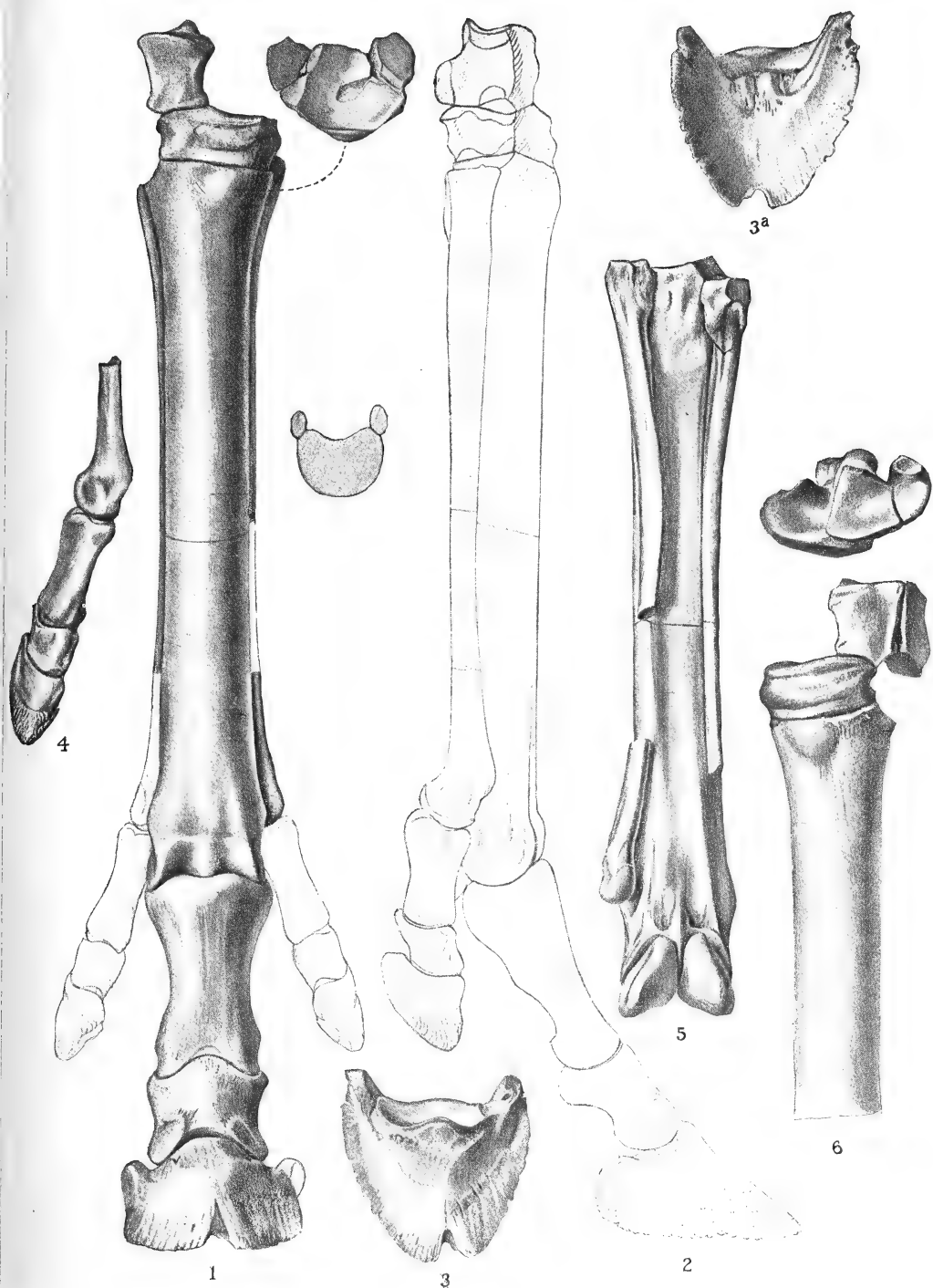
Hipparion (*Neohipparion*) *leptode* Merriam.   Front foot elements, No. 27126 University of California
Collection.   Thousand Creek Pliocene, Nevada.   All figures ×0.45
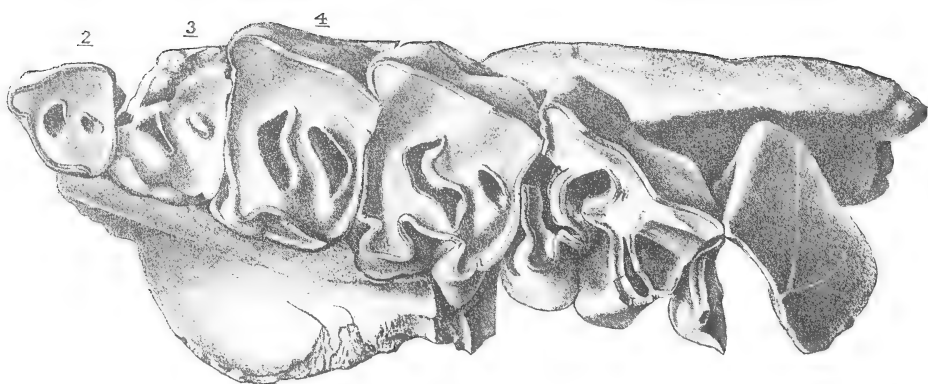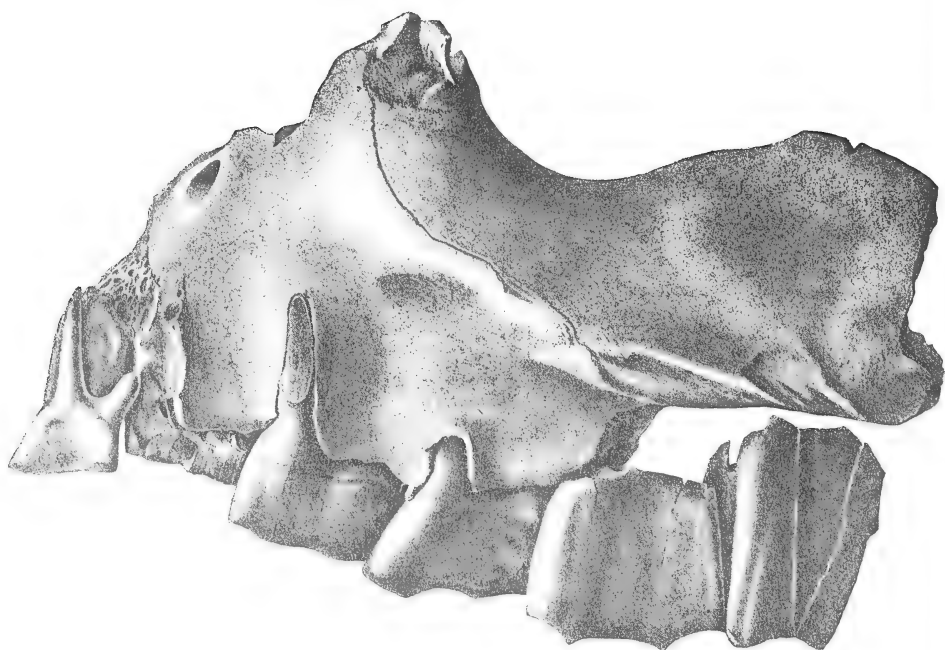
Teleoceras fossiger (Cope). Skull and superior dentition, No. 22901 University of California Collection. Thousand Creek Pliocene, Nevada. Lateral and inferior views, × 0.45
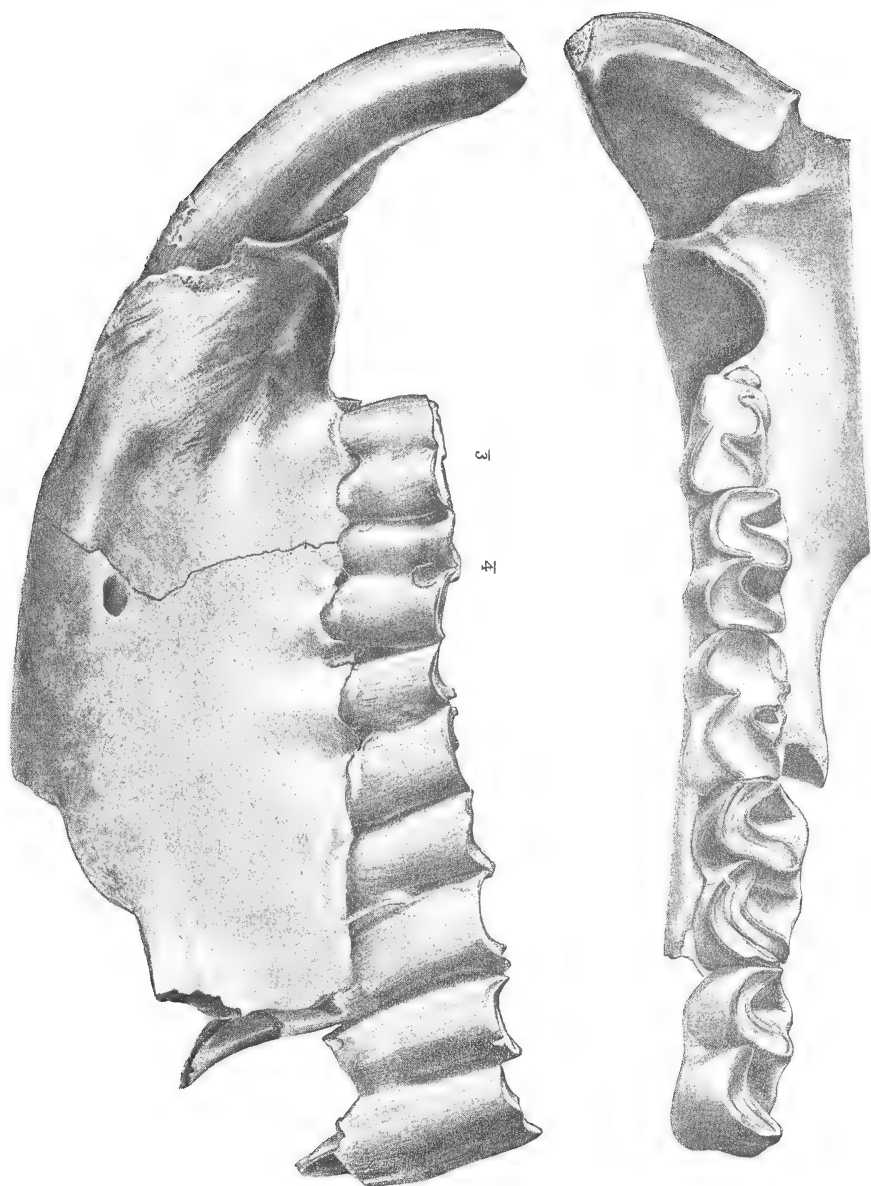
Teleoceras fossiger (Cope). Mandibular ramus and inferior dentition, No. 22901 University of California Collection. Thousand Creek Pliocene, Nevada.
Lateral and superior views, ×0.45

THE OCCURRENCE OF TERTIARY MAMMALIAN REMAINS IN NORTHEASTERN NEVADA

CONTENTS

INTRODUCTION

SEVERAL months ago Professor J. C. Jones of the University of Nevada kindly forwarded to the writer for examination a small collection of mammalian remains found in exposures on the North Fork of the Humboldt River about forty miles northeast of Elko, Nevada. The collection was obtained by Dr. C. W. West of Elko, and by him presented to the University of Nevada. Professor Jones visited the locality at which the bones and teeth had been obtained by Dr. West and secured additional material. Although the specimens obtained are all very fragmentary, it is deemed important to place on record such information as is now available, as it assists materially in interpreting the Tertiary history of Nevada.

OCCURRENCE

The occurrence of the mammalian remains obtained by Dr. West, and the geological relations of the beds in which they were found, were carefully examined by Professor Jones, who has kindly furnished the following discussion of the locality:

The deposit of Tertiary sediments from which the bones were taken is located on the North Fork of the Humboldt River about forty miles northeast of Elko,

near the ranch of George McKnight. The area is included in the beds mapped as Pliocene by the Fortieth Parallel Survey. As noted on their map, these beds cover a wide area in the Elko region.

The bed from which the dark-colored Tertiary bones were taken is a lense of yellow silt showing no signs of stratification and about fifty feet in thickness, lying a short distance above a flow of basic andesite. Both silt beds and basalt dip about twenty degrees to the southwest and the silt projects in two or three small knolls from the face of the hill. The bones are very soft in the damp silt, but on weathering out seem to harden so that they may be safely handled. It will be very difficult to dig the bones from the silt without taking special precautions to preserve them. They are in a fragmentary condition in the silt, and it does not seem likely that a complete skeleton or even a skull will be found in this particular deposit.

There are at least two igneous flows at this locality, a rhyolite and an andesite, together with local lenses of tuff. By tracing them out it may be possible to understand the structure and correlation of the lake beds.

Professor Jones noted also the presence of beds of apparent Pleistocene age in the region of the North Fork of the Humboldt, and within the area mapped as Pliocene by the King Survey.

Composition and Relationships of the Fauna

The total faunal representation from the Tertiary beds at the McKnight locality includes four forms, of which only one, the *Merychippus*, might permit specific determination. The list of forms recognized is as follows:

Merychippus, sp., near isonesus (Cope).	Camelid, sp.
Merycodus?, sp.	Carnivore fragment.

The collection as a whole suggests a faunal stage certainly not older than the Middle Miocene of the Virgin Valley or Mascall, and probably not younger than the Upper Miocene Mohave beds. This assemblage represents a stage more primitive than that of the Ricardo Pliocene, which is the next faunal stage known after the Mohave in the Great Basin. Forms like those found at the McKnight locality have been reported from the Snake Creek Pliocene of the Great Plains region, but they are there associated with much more advanced types. A collection from a horizon with a fauna containing only a small percentage of primitive forms would probably not consist solely of the simpler types without those of more advanced stages.

The little collection from the McKnight locality resembles in gen-

eral the faunal stage of the Cedar Mountain beds southeast of Walker Lake. The Cedar Mountain fauna is in general like that of the Mohave, but may be a somewhat earlier stage. The writer[1] has considered the Cedar Mountain fauna as early Upper Miocene.

The locality at the McKnight Ranch is reported by Professor Jones to be within the limits of the Pliocene as mapped by the Fortieth Parallel Survey of King. It lies approximately in the region from which King[2] described the only Tertiary fauna referred to the Pliocene in the Nevada region. The locality from which the Pliocene fauna is reported by King is described as "Bone Valley, which is drained by the waters of the North Fork of the Humboldt." Mr. S. H. Gester, who has done extensive geologic work in the Elko region, informs me that while working in this area he learned of an occurrence of fossil bones at a locality known as "Bone Valley," situated within the limits of an area a few miles in diameter, which would include the McKnight locality.

The fauna listed by King from Bone Valley, Nevada, consisted of *Merychippus mirabilis*, *Protohippus perditus*, and fragments of *Cosoryx*. The *Merychippus* of King's report may well coincide with that obtained by Professor Jones and Dr. West. A worn tooth of *Merychippus* may easily be confused with *Protohippus*, as has often occurred. The *Cosoryx* mentioned by King is synonomous with *Merycodus* of the collection submitted by Professor Jones.

Considering all of the evidence, it seems to the writer probable that the McKnight locality is stratigraphically, if not geographically, the same as King's Bone Valley Pliocene.

The presumable stratigraphic identity of the Bone Valley Pliocene of King and the McKnight locality, of probable Miocene age, has an important bearing on the Tertiary problem of the middle Nevada region. The age determination of the great extent of deposits in Nevada referred by King to the Pliocene depended to a large extent upon the palaeontologic stage of the Bone Valley collection; upon the relation of this collection to the Niobrara fauna of the Great Plains area; and upon correlation with beds in Oregon considered by King, on the authority of O. C. Marsh, to represent a Pliocene stage. The collections obtained by Professor Jones and by Dr. West from

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[1] Merriam, J. C., Vertebrate Fauna of the Cedar Mountain Beds, Univ. Calif. Publ. Bull. Dept. Geol., 1914. In press.

[2] King, C., U. S. Geol. Expl. of 40th Parallel, vol. 1, p. 439, 1878.

the McKnight locality, as also the material to which reference is made by King, probably represent a faunal stage comprised within the latter half of the Miocene. The fauna of eastern Oregon referred to the Pliocene by Marsh is largely that of the Mascall, which is Middle Miocene. The Niobrara fauna of the Great Plains region, with which the Bone Valley collection may really have some affinity, as suggested by King, is generally considered as Upper Miocene. The palaeontologic basis for age determination of the "Humboldt Pliocene" of King's Shoshone Lake of the Middle Basin area seems, then, to indicate Miocene at what may be considered a typical locality of these beds. Whether other evidence may indicate that a large portion of the deposits mapped as Pliocene by King really represents that period remains to be demonstrated. It seems probable that a considerable part of these deposits may be Miocene. Other portions are probably Pleistocene. The occurrence at Ricardo, on the western border of the Great Basin, of a series of beds representing a faunal and stratigraphic stage which is distinctly pre-Pleistocene, is certainly much later than the Mohave Upper Miocene, and presumably represents early Pliocene, shows that accumulation was taking place in the Basin Region in or near Pliocene time. The difficulties encountered in age determination or correlation of widely separated exposures of Tertiary strata in the Great Basin make one hesitate to accept much, if any, of the Pliocene of King as really representing the Ricardo stage.

The occurrence of mammal remains at the McKnight locality not only changes our views regarding the Pliocene of the Great Basin, but also modifies to some extent the views on distribution of the Miocene originating with King. According to the report of the Fortieth Parallel Survey, Miocene beds are confined to a region west of 117° west longitude, while Eocene does not range west of the 116th meridian. The McKnight locality, situated near 115° 30', is considerably east of King's most easterly Miocene and is east of the most westerly Eocene exposures. A question is naturally raised regarding the relative age of the Tertiary at the McKnight locality and the beds referred to as typical Miocene of the Truckee beds farther west. The Truckee as discussed by King was determined as Miocene almost solely on its lithologic resemblance to the John Day beds of Oregon. The only palaeontologic evidence of contemporaneity of the Truckee with the John Day consisted of a single

rhinoceros tooth referred to *Rhinoceros pacificus*, of the John Day region.   This specimen is not available for comparison.   Within the past few weeks Mr. John P. Buwalda of the University of California, in examining a section of Truckee beds, discovered a considerable part of a mastodon cheek-tooth[3] in the section near Verdi, Nevada.   Proboscideans are absolutely unknown in the John Day Oligocene, but range from the Mascall Middle Miocene up to Pleistocene in the Great Basin.   It is clear that the correlation of the John Day and Truckee is not justified.   No Oligocene is certainly known in the Nevada region.   Mr. Buwalda believes that the Truckee beds are possibly of the same age as the Cedar Mountain Miocene not far to the south, but fully satisfactory evidence of identity in stage is not at hand.

Whether or no the Truckee and Cedar Mountain beds are of the same stage, it is true that deposits of Miocene age seem to range eastward from near the western border of the Great Basin, as stated by King in the Fortieth Parallel Survey report.   The deposits of the McKnight locality are evidently not widely different in age from those of Cedar Mountain and Truckee, and extend the range of the Miocene considerably to the east.

DESCRIPTION OF MATERIAL

MERYCHIPPUS, sp.

The most common remains in the collection from the McKnight locality represent a horse of the genus *Merychippus*.   A number of foot-bones and teeth available seem all to be derived from individuals of the same species.   The recognizable specimens comprise the first and second phalanges, a navicular, and a well preserved lower molar.   The phalanges (fig. 2) may be matched in size and form by specimens from the Mascall and Virgin Valley Middle Miocene of eastern Oregon and northern Nevada.   They may also be matched almost exactly by specimens from the Upper Miocene Mohave beds of the Mohave Desert area, but seem a little smaller than the average of these specimens.   The phalanges are a little more constricted than some available from the Cedar Mountain fauna.

A lower molar, M_1? (fig. 1), also compares closely in size and form with specimens from the Mascall and from the Mohave.   It appears

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[3] Buwalda, J. P., Univ. Calif. Publ. Bull. Dept. Geol.   (In press.)

rather small for average specimens of the Mohave fauna. As the characters of single lower molars of the species of *Merychippus* are not always clearly diagnostic, it is difficult to make a definite specific determination of this specimen.

The various specimens of *Merychippus* taken collectively evidently represent a species of Middle or Upper Miocene age. The species is less advanced than some of the forms of the Mohave Upper Miocene. While small *Merychippus* forms have been reported
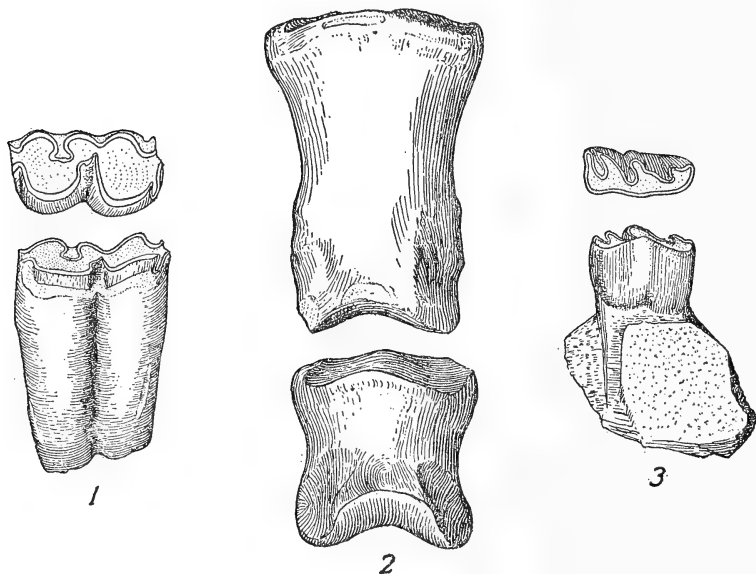
FIGS. 1 TO 3. From Miocene beds, North Fork of Humboldt River, northeastern Nevada.
FIG. 1. *Merychippus*, sp. M_1?, natural size.
FIG. 2. *Merychippus*, sp. Phalanges one and two, natural size.
FIG. 3. *Merycodus?*, sp. P_4?, $\times$ 2.

from the Snake Creek Pliocene, that fauna also contains many advanced horses which are not represented here. It seems improbable that the *Merychippus* species from the McKnight locality represents a faunal stage later than Upper Miocene.

MERYCODUS?, sp.

A single lower premolar (fig. 3) represents P_3 or P_4 of a form which is either *Merycodus* or *Blastomeryx*. The tooth is nearly identical in dimensions with P_4 of a specimen (no. 19805) associated with *Merycodus* antlers and molars from the Cedar Mountain region,

southeast of Walker Lake, Nevada.   It has been noted that in the Cedar Mountain specimen the characters of the inferior premolars are rather more primitive in some respects than in the *Merycodus* form of the Mohave fauna.   The degree of hypsodonty of the Cedar Mountain specimen seems less than in the Mohave form, and the posteroexternal groove is less marked.   In this respect the specimen seen in figure 3 agrees with the form from the Cedar Mountain beds, and probably represents a similar type.   It may tentatively be referred to *Merycodus*, and may represent *M. furcatus*, or a more primitive form.   The form represented in this specimen most nearly resembles types known in the Upper Miocene.

CAMELID?, Various Forms

Several fragments of cheek-teeth represent indeterminate camels. One is a large form, possibly *Pliauchenia.*

CARNIVORE REMAINS

The fragmentary distal end of a metapodial from the McKnight locality probably represents a large cat, but may be canid.

SUMMARY

The McKnight locality in the valley of the North Fork of the Humboldt River, Nevada, furnishes a mammalian fauna probably representing a stage comprised within the latter half of the Miocene. This fauna is near the stage of the Cedar Mountain and Mohave faunas referred to the Upper Miocene.

The McKnight locality is probably of the same stratigraphic stage as the locality from which the Fortieth Parallel Survey obtained the fauna furnishing the principal evidence of age for the large area mapped as Pliocene by that survey.

The deposits at the McKnight locality mapped as Pliocene by the Fortieth Parallel Survey are not improbably near the age of the Truckee beds, mapped as Miocene, in the western portion of the Great Basin region.

The Miocene of Nevada extends much farther to the east than the easternmost limits heretofore recognized.

Transmitted August 28, 1914

MAMMALIA

FAUNA OF THE MOHAVE DESERT AND STEWART VALLEY, NEVADA

A COLLECTION OF MAMMALIAN REMAINS FROM TERTIARY BEDS ON THE MOHAVE DESERT

THROUGH the kindness of Mr. John R. Suman of the University of California, the writer has recently received an interesting collection of mammalian remains obtained by Mr. H. S. Mourning of Los Angeles, from deposits exposed in the Mohave Desert region, about ten miles northwest of Barstow, San Bernardino County, California. Mr. Mourning and Mr. Suman very kindly presented the collection to the University. This material is of especial interest as it represents a mammalian fauna which may serve as a basis for correlation with faunas of the well-known mammal-bearing epicontinental formations of the basin and great plains regions to the east, and may thus assist in determining the relation of the Tertiary geologic scale of California to that of the interior region.

As yet nothing is known regarding the nature of the formation in which the collection was obtained. According to a sketch map published by Hershey[1] the point at which the collection was made would fall within the limits of what is designated by Hershey as the Rosamond series. This series has not, however, been characterized in any way, so that the nature of the formation is unknown. As geographic location is one of the important factors concerned, the horizon at which this collection was obtained may be referred to under a geographic designation as the Mohave beds.

The collection presented to the University consists of about one hundred specimens representing teeth, portions of jaws, antlers, and foot-bones. The following forms are represented:

> *Merychippus*, near *calamarius* (Cope)
> *Merychippus*, sp. indet.
> *Merycodus necatus* Leidy
> *Procamelus* (?), sp.
> *Pliauchenia* (?), sp.

[1] Hershey, O. H., Univ. Calif. Publ. Bull. Dept. Geol., vol. 3, opposite p. 3. 1902.

The greater number of the horse remains represent a species related to *Merychippus calamarius* described by Cope from the Santa Fe Upper Miocene. The Mohave form is represented by teeth of a more advanced type than those in the Middle Miocene of the Mascall and Virgin Valley beds. The crowns (pl. 29, figs. 1*a* to 3*b*) are longer and somewhat larger in cross-section than any of the forms from the Mascall or Virgin Valley. They are, however, to be included in *Merychippus* rather than in any of the more advanced genera.

A worn tooth (pl. 29, fig. 4) in the collection differs enough in dimensions from the other specimens to suggest that it may represent a species still more advanced than the one just described.   It may, however, be included with the other forms.

A number of astragali (pl. 29, fig. 5) and phalangeal elements of the *Merychippus* type show considerable differences in size and form and may represent more than one species.

The *Merycodus* remains consist of fragments of antlers evidently representing more than a dozen individuals.   Several of these

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EXPLANATION OF PLATE 29

FIGS. 1*a* TO 3*b*.   *Merychippus*, near *calamarius* (Cope).   Ten miles northwest of Barstow, San Bernardino County, California.

Figs. 1*a*, 1*b*, and 1*c*.   Upper molar, no. 17370, natural size.   Fig. 1*a*, occlusal view; 1*b*, anterior view; 1*c*, exterior view.

Fig. 2.   Upper molar with unworn cusps, no. 17371, natural size.

Figs. 3*a* and 3*b*.   Lower molar, no. 18599, natural size.   Fig. 3*a*, occlusal view; 3*b*, lateral view.

FIG. 4.   *Merychippus*, sp. indet.   Worn upper molar, no. 18600, natural size. Ten miles northwest of Barstow, San Bernardino County, California.

FIG. 5.   *Merychippus* (?).   Astragalus, no. 18601, natural size.   Ten miles northwest of Barstow, San Bernardino County, California.

FIGS. 6 TO 8.   *Merycodus necatus* Leidy.   Ten miles northwest of Barstow, San Bernardino County, California.

Fig. 6.   Portion of a tip of an antler, no. 17375, natural size.

Fig. 7.   Antler, no. 18602, natural size.

Fig. 8.   Portion of an antler split through the fork, no. 17374, natural size.
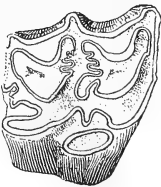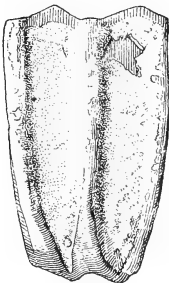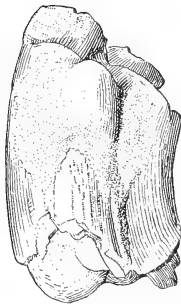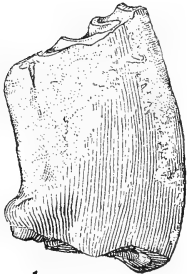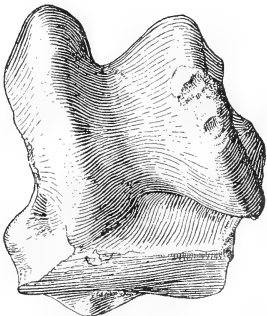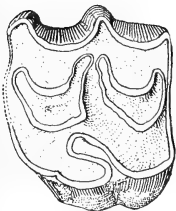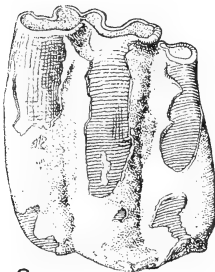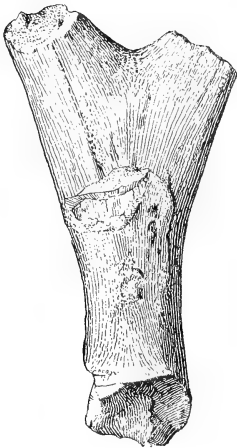
specimens are well enough preserved to show the shaft of the horn up to a point above the bifurcation (pl. 29, fig. 7). Other fragments show the terminal portion of the horn (pl. 29, fig. 6). The form represented in these specimens, as shown particularly in plate 29, figure 7, seems identical with that of *Merycodus necatus* Leidy of the Nebraska Upper Miocene. This animal must have been a common form in the Mohave region in Upper Miocene time, judging by the relatively large number of specimens obtained.

The camel remains found comprise astragali and proximal phalangeal elements which seem to represent two species, one considerably larger than the other. The smaller form may represent *Procamelus*, the larger one *Pliauchenia*, but a satisfactory determination is not possible with the material at hand.

The common species of *Merycodus*, and the horse most abundantly represented in the collection, taken together indicate that the age of this fauna is approximately Upper Miocene. The camel remains do not negative this determination. It seems improbable that later collections will show sufficient material of a more primitive or less advanced type to indicate that this particular horizon is of Middle Miocene age. On the other hand, the absence of horses distinctly advanced beyond the *Merychippus* type indicates a period earlier than Pliocene.

As fragmentary as this collection is, the species included in it unavoidably suggest a close faunal connection with the great plains region during Upper Miocene time. It is also interesting to note that as yet no faunal phase of the Miocene corresponding to the Mohave stage is known in eastern Oregon or in northern Nevada; as also that there is reason to suppose that a cycle of erosion rather than of deposition was in progress in these regions in Upper Miocene time.

Transmitted February 24, 1911

A PECULIAR HORN OR ANTLER FROM THE MOHAVE MIOCENE OF CALIFORNIA

IN A collection of mammalian remains from Miocene beds in the Mohave Desert recently obtained by H. S. Mourning and J. P. Buwalda, there is a horn or antler of peculiar type, unlike any form known to the writer. This specimen is described in advance of a discussion of the whole fauna, in the hope that a fuller expression of opinion may be obtained through the discussion.

The specimen consists of a single fragmentary horn or antler (no. 20052), which had been considerably weathered. It was found at the University of California collecting locality, no. 2057, in the Mohave Miocene north of Barstow, California. From earlier studies the fauna in the beds of this region has been considered as upper Miocene.[1] Much larger collections than those originally available are now at hand for study, and it is possible that in this material more than one faunal zone may be represented, but the largest part of the Mohave Beds seems quite certainly to represent an upper phase of the Miocene.

The portion of the horn or antler represented in specimen 20052 consists of a part of the beam, which divides into two nearly equal branches diverging almost horizontally. Upon the nearly even superior surface of the branches are a considerable number of small spikes or papillae. Of the two branches, one is projected approximately in the plane of the flattened beam. The other branch curves rather sharply away from this plane. (See fig. 2.) The branch bending away from the plane of the beam is the smaller. A number of the superior spikes or papillae bend out at a low angle from the convex side of the curve formed by the two branches. It seems probable that the plane of the beam was anteroposterior rather than transverse to the skull, and that the papillae on the convex side of the bow are on the outer or lateral, rather than on the inner

[1] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 169, 1911.
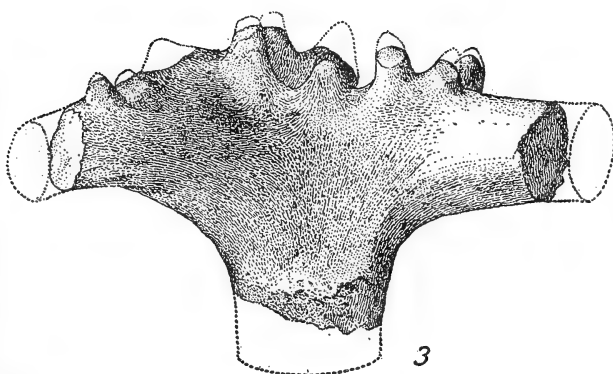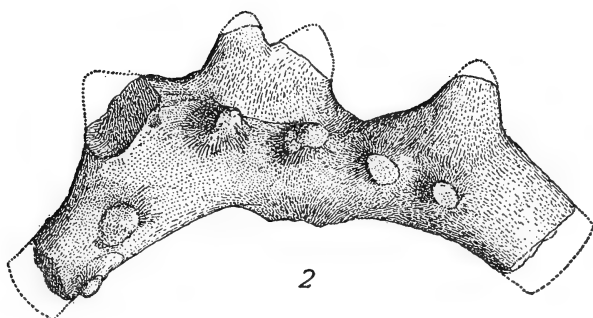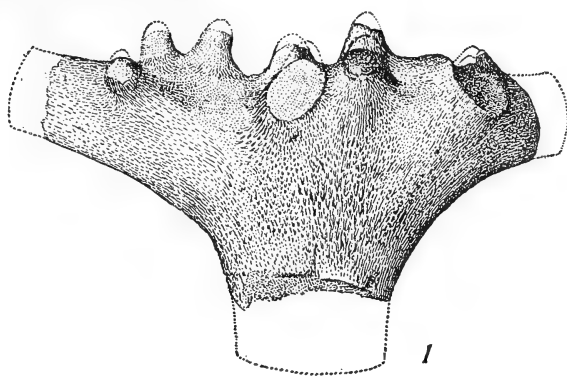
FIGS. 1, 2, AND 3. *Merycodus coronatus*, n. sp. No. 20052, natural size. Mohave Beds, Mohave Desert, California. Fig. 1, outer side of horn; fig. 2, superior aspect of horn; fig. 3, medial side of horn.

side of the horn. If the smaller of these two horizontal branches is the anterior, this is the right horn.

The spikes or papillae on the upper side of the horn are in two rows. There are six on the concave side, and four on the convex side. The inner six are arranged in three pairs. Of the outer four there is a single large spike opposite the posterior inner pair and a similar one opposite the space between the anterior and middle inner pairs, and a pair of papillae arising from a common base opposite the middle inner pair. The inner papillae are nearly erect excepting the most anterior one. The papillae on the outer side are directed outward at a low angle.

Judging from the single specimen available, the anterior branches of the right and left horns of this animal curved in toward each other over the face, the other branch extended backward and slightly inward, making a crown-like or horseshoe-like structure above the head. One row of the small spikes or papillae was directed upward, and the other row was directed outward around the margin of the crown.

Specimen 20052 most nearly resembles the horn or antler of *Merycodus*, which it also approaches in size, and to some extent in the texture of the horn. It differs from *Merycodus* in the form of branching, and in the presence of the double row of superior spikes. The texture of the surface of specimen 20052 differs somewhat from that of any of the numerous *Merycodus* horns available from the Mohave Miocene. In no. 20052 the surface is marked by numerous wavy reticulating lines or ridges, which are not matched exactly on any available *Merycodus* specimen. It is possible that the contrast is due in part to condition of weathering, but it seems partly due to difference in structure.

The peculiarity of specimen 20052 may be accounted for on the assumption that it is a "sport" or "monstrosity" of *Merycodus necatus*, a common form in the Mohave region. A large number of *Merycodus* horns have been found in the Mohave Beds, but on no other specimen has there been noted any suggestion of the form seen in no. 20052, so that there was no common tendency to develop this type of horn.

Specimen 20052 represents a type distinct from the other available specimens of the Mohave fauna and, so far as the writer is aware, it is the only known specimen. This may possibly be urged

against the view that it is an undescribed form, and not a variation or a sport of a known *Merycodus* species. In this connection it should be noted that the Mohave fauna is as yet very imperfectly known, and that a considerable number of the most important elements in the fauna have been represented by single fragmentary specimens. For a considerable time the oreodont group was known from the Mohave region only by a fragment of a lower jaw with two imperfect teeth, this being the only oreodont found in an area including all of California and nearly all of Nevada.
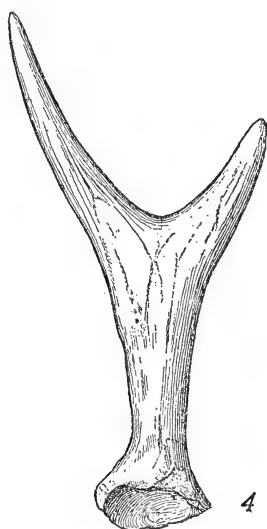
FIG. 4. *Merycodus necatus* Leidy. Outer side of horn. No. 19832, × ½. Mohave Beds, Mohave Desert, California.

If the peculiar horn here described represents a type heretofore unknown, it would appear to be a form nearly related to *Merycodus necatus*, the common Mohave species. (See fig. 4.) *Merycodus necatus* is characterized by the possession of a short horn with a short, wide, flattened beam, from the broad summit of which two nearly equal branches arise. The form seen in no. 20052 would be produced by flaring the branches, bending them toward the branches of the opposite horn, and developing the superior spikes or papillae.

While the writer is not inclined to consider the specimen seen in no. 20052 as certainly representing a new type of horn or antler, or a previously undescribed animal, it seems desirable to give a specific

designation to this type, which may be known as *Merycodus coronatus*. While the form of horn or antler seen here suggests various kinds of antlers of the modern Cervidae, there is no evidence to indicate that this Miocene animal represents anything more than a foreshadowing of a modern type.

Transmitted June 28, 1913

NEW ANCHITHERIINE HORSES FROM THE TERTIARY OF THE GREAT BASIN AREA

CONTENTS

INTRODUCTION

WITHIN the past two years, four expeditions from the University of California have visited the southern portion of the Great Basin region to search for vertebrate remains in Tertiary deposits. One party investigated the region southeast of Walker Lake, Nevada, in 1912, and three parties have worked in the Mohave Desert area in 1911, 1912, and 1913.

Of numerous palaeontologic contributions made by these expeditions, among the most interesting is the discovery of two anchitheriine horses presenting phases of structure or stages of development not previously known in the groups with which they are most nearly allied.

The first specimen found was obtained by Lawrence C. Baker in the Mohave Miocene of California in April, 1911. It represents the lower jaw of a form showing characters near those of both *Parahippus* and *Archaeohippus*. A fragmentary upper jaw, evidently belonging to an animal of the same species as that found by Mr. Baker, was discovered in the Mohave Beds by J. P. Buwalda and H. C. Mourning in January, 1913.

The second type of anchitheriine horse discovered is represented

by a slab containing scattered parts of a skeleton obtained in the region southeast of Walker Lake, Nevada, by Baker and Buwalda in May, 1912. This specimen had previously been seen by Mr. T. H. Buck of Mina, Nevada. It was through the kindness of Mr. Buck that the slab was pointed out to Baker and Buwalda. The writer wishes to express his thanks for the kind assistance given by Mr. Buck in bringing the specimen to the railway station for shipment.
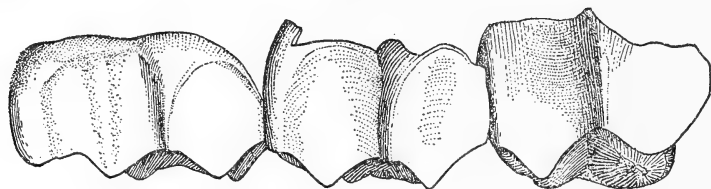
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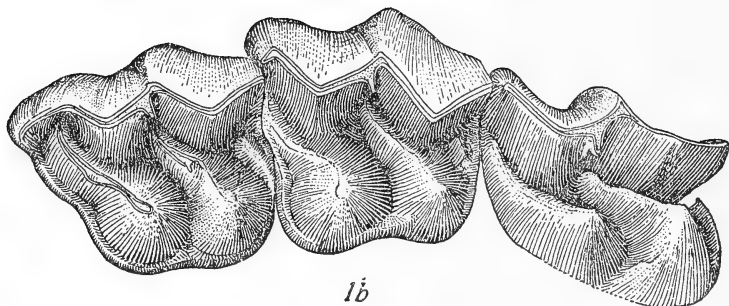
1b

FIGS. 1a AND 1b. *Hypohippus* (*Drymohippus*) *nevadensis*, n. sub-gen. and n. sp. Upper milk molars. No. 21056, natural size. Fig. 1a, lateral view; fig. 1b, occlusal view. Stewart Valley Beds, southwestern Nevada.

HYPOHIPPUS (DRYMOHIPPUS[1]) NEVADENSIS, n. sub-gen. and n. sp.

Type specimen no. 21056, University of California Collections in Vertebrate Palaeontology. From the Stewart Valley Miocene, twenty-four miles northeast of Mina, Nevada.

Characters much as in *Hypohippus*, but metaloph of milk molars not connected with ectoloph.

The type specimen consists of a small portion of the skull with three milk molars, portions of all four limbs, and a number of scat-

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[1] δρυμός, wooded dell or glade; ‘ίππος, horse.

tered fragments of other skeletal parts. The elements of the limbs were in part connected.

Skull and Dentition.—The greater portion of the skull had been weathered away before the specimen was discovered. All that remains consists of a portion of the lower region of the cranium. Fortunately it was embedded in such a manner that it faced into the rock, and only the roots of the teeth were damaged. The portions of the cranium present show little of significance.

The dentition (figs. 1*a* and 1*b*) shows three well-preserved cheek-teeth. The incisors are not present. The cheek-teeth represent the milk dentition with Dm⁴ just coming into function. They are referred to the milk dentition as they are relatively narrower than P² to P⁴ of nearly related forms.

The teeth of no. 21056 represent an animal larger than any of the known forms of *Hypohippus*, but approaching in size *Hypohippus affinis*, the largest described species. They are absolutely larger than the permanent premolars of *H. osborni*, and larger than the milk molars of the type specimen of *H. affinis*. The excess in dimensions is evident in both the anteroposterior and transverse diameters.

COMPARATIVE MEASUREMENTS OF DENTITION

	Milk dentition		Permanent dentition	
	H. nevad-ensis No. 21056	H. affinis Type specimen	H. osborni	H. equinus
Dm², anteroposterior diameter along outer border	33 mm.	....	P² 27.3	25
Dm², greatest transverse diameter	29	....	P² 26	25
Dm³, anteroposterior diameter along outer border	31.8	....	P³ 25.4	25
Dm³, anteroposterior diameter measured through protoconule and hypostyle	29	....	P³ 24	22 *b*
Dm³, greatest transverse diameter	30.5	....	P³ 30	27
Dm⁴, anteroposterior diameter along outer border	31.9 *ap.*	28.5 *ap.*	P⁴ 30	25
Dm⁴, anteroposterior diameter measured through protoconule and hypostyle	....	26.7 *a*	P⁴ 25	22 *b*
Dm⁴, greatest transverse diameter	31.4	29	P⁴ 30	26

a, measurements from J. Leidy's figure of type specimen.
b, from W. B. Scott's figures of type specimen.
ap, approximate.

In form and pattern of the milk molars the Nevada specimen resembles in general the permanent dentition of *Hypohippus osborni*. The protoconule portion of the protoloph seems a little more dis-

tinctly marked off from the protocone in Dm² than in P² of *H. osborni*. In Dm³, however, the protoconule region of no. 21056 seems less distinct than in P³ of *H. osborni*. In Dm² of no. 21056 the longitudinal ridge or rib on the outer side of the paracone is much less distinct and the parastyle is more prominent than in P² of *H. osborni*. A small but distinct hypostyle is seen on Dm² and Dm³. The size of the hypostyle is near that in the premolars of *H. osborni*. On Dm² there is a strong shelf of the cingulum extending around the anterior and inner sides and into the hypostyle region posteriorly. On Dm³ the cingulum is faintly interrupted on the inner side opposite the middle of the protocone, and fully interrupted on the inner side of the hypocone.

The principal difference between the Nevada specimen, no. 21056, and *Hypohippus osborni* is found in the separation of the outer end of the metaloph from the ectoloph. In none of the milk molars of the Nevada specimen is the summit of the outer end of the metaloph connected with the ectoloph. In Dm² and Dm³ the base of the metaloph barely reaches the base of the ectoloph. In Dm⁴ the base of the metaloph scarcely reaches the base of the ectoloph. In each of these teeth there is a small transverse ridge or tubercle pointing inward from the ectoloph at the posterior end of the paracone crescent. This transverse prominence arising from the ectoloph extends inward near the outer end of the metaloph but fails to meet that ridge. The outer end of the metaloph tends to swing a little in front of the inner transverse prominence of the ectoloph.

The inner transverse prominences arising from the ectoloph attain their greatest elongation or height near the summit of the ectoloph, and rapidly diminish in height as they extend toward the base of the tooth. On Dm⁴ the transverse prominence consists of two small tooth-like projections. On the longer or lower of these points the diameter, parallel with the height of the tooth crown, is not more than twice the anteroposterior diameter. The second projection, situated farther toward the base of the ectoloph, is an exceedingly small tubercle. The smaller projection does not reach the bottom of the valley between metaloph and metacone crescent. On Dm³ the inner transverse prominence of the ectoloph is very small, and is situated near the crest of the ectoloph. On Dm² the prominence is higher, but is reduced rapidly at the proximal end and does not connect with the metaloph.

A certain significance may attach to the situation of the inner transverse ridge of the ectoloph. In the milk teeth of the Nevada form, this transverse crest or ridge rests upon the posterior end of the paracone crescent. In a permanent upper molar (no. 11570) of *Hypohippus* from the Middle Miocene of Virgin Valley, Nevada, the connection between metaloph and ectoloph is established at the posterior end of the paracone crescent. In the cheek-teeth from P² to M³ in *H. osborni* the inner transverse ridge of the ectoloph arises almost exactly at the junction of the paracone and metacone crescents. In no. 12564, a very narrow *Hypohippus* tooth from the Virgin Valley Miocene of northern Nevada, the union of metaloph and ectoloph seems to be as in *H. osborni*. In the original reference to tooth no. 12564 the writer suggested[2] that this form might represent a species distinct from no. 11570, which is much wider anteroposteriorly and shows the more anterior position of the inner transverse ridge of the ectoloph.

The separation of metaloph and ectoloph as noted in the milk teeth of specimen no. 21056 is a matter of considerable interest in the classification of the Equidae. In *Mesohippus* the metaloph and ectoloph are separate, and a small transverse ridge or wrinkle may arise from the inner side of the ectoloph in the same situation as that in the milk teeth of the Nevada specimen, no. 21056. In *Miohippus*, as represented by specimens from the John Day series, the metaloph is usually separated from the ectoloph. In *Anchitherium, Hypohippus*, and *Archaeohippus* the metaloph is completely united with the ectoloph. The stage of advance of the cheek-teeth in the Nevada specimen, no. 21056, is near that of *Miohippus* so far as the relation of the metaloph to the ectoloph is concerned, and in this character it differs from the known forms of *Anchitherium, Archaeohippus*, and *Hypohippus*. In general form of the cheek-teeth and in the relation of protocone to protoconule, specimen no. 21056 is of the *Hypohippus* type. In *Mesohippus, Miohippus, Archaeohippus*, and *Anchitherium*, the protocone and protoconule are distinctly separated, in *Hypohippus* and in the Nevada specimen the protoconule is small, and is almost completely merged with the protocone.

As the teeth in specimen no. 21056 correspond so closely to the

[2] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, pp. 259 and 260, 1911.

general type of cheek-teeth in *Hypohippus*, the hypothesis that the milk molars of typical *Hypohippus* might show the primitive character of the Nevada specimen naturally suggested itself. Leidy's
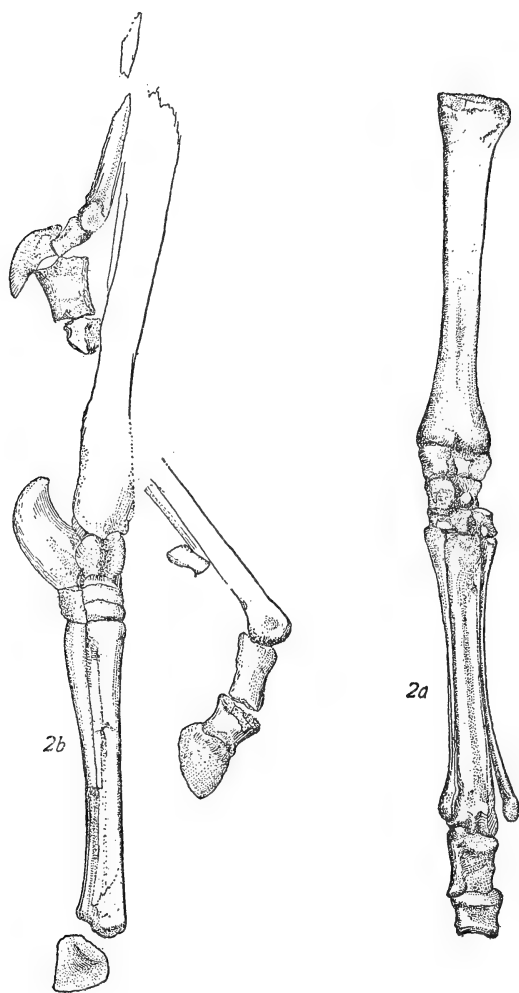
FIGS. 2a, 2b, AND OTHER FRAGMENTS. *Hypohippus* (*Drymohippus*) *nevadensis*, n. subgen. and n. sp. Portions of limbs. No. 21056, $\times \frac{1}{5}$. Fig. 2a, anterior limb; fig. 2b, posterior limb. Stewart Valley Beds, southwestern Nevada.

type of *Hypohippus affinis*, the typical species of that genus, is a milk tooth, but the specimen shows no suggestion of separation of metaloph and ectoloph. It is slightly worn, but a corresponding degree of wear in Dm⁴ of the Nevada form would not tend in any

way to connect metaloph and ectoloph. Dr. W. D. Matthew, who has very kindly examined such milk teeth of *Hypohippus* as are present in the collections of the American Museum of Natural History, finds that in all of the specimens the metaloph and ectoloph are connected.

The Nevada form represented by specimen 21056 seems, therefore, to represent a type with dentition in general close to that of *Hypohippus*, but distinguished especially by the less advanced stage of evolution of the metaloph in the temporary molars.

Limbs.—Portions of both the anterior and posterior limbs (figs. 2*a* and 2*b*) exhibit some of the essential characters, but parts of each of the feet had been carried away before burial, or had been destroyed by weathering before the specimen was found. The general character and proportions of the parts of the extremities preserved are near those of *Hypohippus*. The lateral digits and their ungual phalanges are relatively large, and were evidently functional. The first and second phalanges of the median digit are relatively shorter and wider than in the *Merychippus* forms of the Miocene. The ungual phalanx of the median digit is broad, and the lateral wings show a stage of development at least as advanced as in *Hypohippus*. Metacarpal three shows a distinctly oblique lateral facet for articulation with the unciform. In metatarsal three there seems to be a very small and quite oblique facet for the cuboid. In general the limb structure resembles that of *Hypohippus*.

MEASUREMENTS OF LIMB ELEMENTS

Radius, greatest length of shaft.................................. 241   mm.
Radius, least width of shaft....................................... 25
Metacarpal II, greatest length.................................... 190
Metacarpal III, greatest length................................... 192
Metacarpal III, width of distal end, approximate.................... 28.5
Phalanx I, digit III of anterior extremity, greatest length........... 40
Phalanx I, digit III of anterior extremity, greatest width............ 30
Phalanx II, digit III of anterior extremity, greatest length.......... 30
Phalanx II, digit III of anterior extremity, greatest width........... 31
Metatarsal III, greatest length................................... 203
Metatarsal IV, greatest width at proximal end...................... 17
Phalanx I, lateral digit (hind foot?) greatest length along superior side.. 23.5
Phalanx III, lateral digit (hind foot?) length along superior side 35

Relationships.—The form represented by the Nevada specimen, no. 21056, resembles *Hypohippus* in the characters of the limbs and

in the general form of the cheek-teeth. It differs from *Hypohippus* in the separation of metaloph and ectoloph in the milk dentition. It is uncertain whether the permanent dentition of this species is represented in any of the collections from the Great Basin region. A difference in tooth characters comparable to that separating this species from typical *Hypohippus* is ordinarily considered as of generic value. In this particular case, the total characters, so far as known, indicate that the species is much nearer to *Hypohippus* than to any other group, and excepting the separation of metaloph and ectoloph is not clearly distinguished from that genus. Viewed from the most unfavorable angle, the gap between this form and typical *Hypohippus* seems less than the spaces between other anchitheriine genera. The writer has therefore tentatively included this species in the *Hypohippus* group, with the suggestion of incipient separation indicated in the subgeneric distinction. The new subgenus, *Drymohippus*, proposed to include this form, bears the characters of *Hypohippus* excepting in the separation of metaloph and ectoloph in the milk dentition. Later investigations may add other distinctive characters.

Parahippus(?) mourningi,[3] n. sp.

Type specimen no. 19840, a portion of a maxillary with milk dentition and M^1. Paratype, a portion of a mandible, no. 19764, with dentition representing P_2 to M_2. Both specimens from the Mohave Miocene, Mohave Desert, California.

A portion of a lower jaw with dentition (figs. 5*a* and 5*b*) obtained by Mr. Baker in 1911 was recognized by the writer as representing a horse with characters near *Parahippus* and *Hypohippus*, but with size and stage of evolution suggesting *Archaeohippus*. The specimen differed, however, from the only lower jaw material referred to *Archaeohippus* in several characters, and especially in the absence of the strong internal cingulum shown on teeth referred to *Archaeohippus* by Gidley.[4] In January, 1913, a second specimen, a maxillary (fig. 3) with Dm^3 Dm^4, and M^1, representing a very small brachyodont horse, was obtained in the Mohave region by Buwalda and Mourning, and again the resemblance to the genera *Parahippus*, *Hypohippus*, and *Archaeohippus* appeared. An approximation of

[3] This species is named in honor of Mr. H. S. Mourning, through whom the first specimens from the Mohave region came into the writer's hands.

[4] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 22, p. 385, 1906.

the dimensions of the cheek-tooth series, as well as a comparison of individual teeth, shows that the upper and lower jaw specimens represent animals of very nearly the same size.   The similarity of dimensions, considered with similarity of relationship to other forms and similarity of occurrence, leaves little room for doubt that the two jaws represent the same species.

The species represented by specimens 19840 and 19764 seems distinct from any form thus far described.   In spite of its fragmentary nature, the upper jaw specimen is selected as the type, as the characters of the superior cheek-tooth series seem more significant in discussion of the relationships.

Upper Cheek-teeth.—In the specimen representing the upper jaw (fig. 3), the well-preserved, unworn, inner portion of M¹ offers good
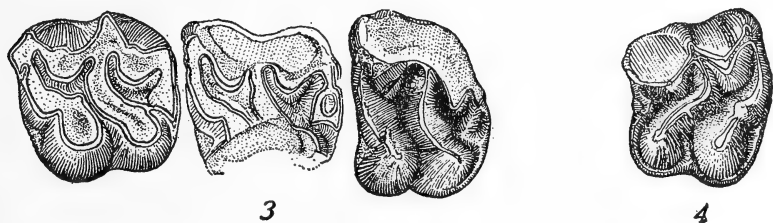
Fig. 3.   *Parahippus*(?) *mourningi*, n. sp.   Dm³, Dm⁴, and M¹.   No. 19840, × 1½.   Mohave Miocene, Barstow Syncline, Mohave Desert, California.

Fig. 4.   *Archaeohippus ultimus* (Cope).   Upper molar.   No. 1689, × 1½.   Middle Miocene, Mascall Beds, Eastern Oregon.

opportunity for examination of certain distinctive characters of this form.   In this tooth the metaloph is fully united with the ectoloph. The protoconule is distinctly separate from the protocone, it is considerably elongated and flattened, and its inner end slightly overlaps the protocone.   The hypostyle is larger than in *Hypohippus* and *Archaeohippus*, and there is a more distinct cup-like depression behind it.   There is no suggestion of a crochet, though several plate-like projections arise from the anterior side of the outer end of the metaloph.   The cingulum is well developed on the posterior side, and less distinctly on the anterior side between protocone and protoconule.   There is no shelf of the cingulum on the inner or lingual side of the tooth.   The cusps or ridges of the crown are somewhat higher than in *Archaeohippus* or in *Hypohippus*.   The surface shows a degree of rugosity more pronounced than seems char-

acteristic of *Hypohippus* or of *Archaeohippus*. No trace of cement is evident upon the crown.

The crowns of the milk molars of the Mohave specimen were apparently somewhat shorter and slightly rougher than those of the permanent molars. As in the permanent dentition, the milk molars show the metaloph connected with the ectoloph, there is no internal or lingual shelf of the cingulum, and the hypostyle is large. On one of the milk molars there is a faint suggestion of crinkling of the anterior side of the outer end of the metaloph. A P² from the Mascall Miocene considered by Gidley to represent *Archaeohippus* differs from the milk molars of the Mohave specimen in showing much greater development of the longitudinal ribs on the outer side of the paracone and metacone. There is a very faint longitudinal rib on the outer face of the paracone in Dm³ of the Mohave specimen. A longitudinal rib is barely perceptible on the outer side of the metacone of this tooth.

MEASUREMENTS

	No. 19840	Archaeohippus ultimus Type specimen	Archaeohippus ultimus No. 1689
Dm³, greatest anteroposterior diameter.........	13 mm.	P³ 12	....
Dm³, transverse diameter......................	13.8	P³ 16	....
Dm⁴, greatest anteroposterior diameter.........	13.7	P⁴ 13	....
Dm⁴, transverse diameter.....................	a14.5	P⁴ 17	....
M¹, anteroposterior diameter measured along middle of crown..........................	13.7	M¹ 11	....
M¹, approximate transverse diameter measured along anterior border......................	a16	M¹ 15	....
M³, anteroposterior diameter measured along middle of crown..........................	....	11	11
M³, transverse diameter along anterior border...	....	14	14.8

a, approximate.

The form of the cheek-teeth shown in the upper jaw of no. 19840 differs from *Hypohippus* in the greater height of the crown, larger protoconule and metaconule, larger hypostyle, and more abrupt inner wall of protocone and hypocone. From *Archaeohippus* no. 19840 differs in its somewhat higher, more rugose crown; larger, more compressed protoconule; much larger hypostyle with posterior cup; and absence of internal cingulum. From typical *Parahippus* the Mohave specimen differs in absence of the crochet, and in its small

size. The Mohave form seems to be distinguished from *Anchitherium* by relatively smaller size of the protocone and absence of internal cingulum.

Lower Cheek-teeth.—The lower jaw specimen, no. 19764, (figs. 5*a* and 5*b*) represents a form which in size is near *Miohippus*. The cheek-teeth are brachyodont, without evidence of cement covering. The crowns of the molars and premolars are slightly rugose, and tend to be somewhat higher than in the average *Hypohippus*.

P_4 is considerably larger than M_1 in both anteroposterior and transverse diameter. The metaconid and metastylid show a distinct tendency to separate at the summit, the separation being more marked than in typical *Hypohippus*, and less advanced than

5*a*
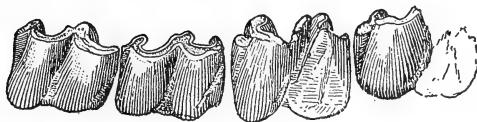
5*b*

Figs. 5*a* and 5*b*. *Parahippus*(?) *mourningi*, n. sp. P_3 to M_2. No. 19764, natural size Fig. 5*a*, occlusal view; fig. 5*b*, outer side. Mohave Miocene, Barstow Syncline, Mohave Desert, California.

in typical *Parahippus*. The entostylid is well developed. The cingulum is well shown on the anterior and posterior sides of the crown, but shows no distinct shelf on the outer and inner sides.

This specimen represents an anchitheriine horse smaller than any known to the writer from post-Oligocene horizons, excepting *Archaeohippus*. It is in some respects intermediate between *Hypohippus* and *Parahippus*. As *Archaeohippus* also represents a small form more advanced than *Hypohippus* and less advanced than *Parahippus*, it might be suspected that the Mohave species is allied to it.

The only known material representing the lower jaw of *Archaeohippus* available for comparison consists of two fragmentary speci-

mens from the Mascall Miocene, the typical horizon of that genus. This material was referred to *Archaeohippus* by Gidley.[5] The principal specimen is a piece of a lower jaw with P^3 and P^4, and the roots of P^1 and P^2. The teeth present are unfortunately much worn, and the nature of the cusps cannot be determined. The important characters shown are the dimensions of the premolars, and the well-developed internal basal cingulum on the molariform teeth. It seems probable that Gidley's reference of the lower teeth from the Mascall to the genus *Archaeohippus* is correct, as these teeth resemble the typical upper teeth in the presence of a basal cingulum, just as the lower teeth from the Mohave Beds resemble the upper teeth from that region in the absence of cingula excepting at the anterior and posterior ends.

The dentition of specimen 19764 differs from the lower teeth referred to *Archaeohippus* by Gidley in the absence of external and internal cingula, and apparently also in the proportions of the premolars.

The form represented by the lower jaw, no. 19764, shows a general resemblance to *Hypohippus*, but differs in its slightly higher and more rugose crowns, more clearly marked incipient separation of metaconid and metastylid columns, and absence of external basal cingulum.

The lower jaw differs from typical *Parahippus* in the very weak separation of the metaconid and metastylid columns, and in the absence of cement from the crowns. The separation of metaconid and metastylid in no. 19764 shows but little advance beyond the stage seen in the dentition of a *Hypohippus* specimen from Virgin Valley.[6] In none of the cheek-teeth of no. 19764 are metaconid and metastylid pillars separated on the inner side by more than a faint groove at the summit.

The character of the dentition in the lower jaw specimen, no. 19764, does not agree fully with any of the described genera. It is intermediate between *Hypohippus* and *Parahippus*, and evidently approximates *Archaeohippus* in many respects. So far as the stage of evolution is concerned, the Mohave form would seem to come fairly near *Parahippus*. It shows elongation of the crown, the

[5] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 22, p. 385, 1906.

[6] See Gidley, J. W., Univ. Calif. Publ. Bull. Dept. Geol., vol. 5, p. 236, fig. 1, 1908.

lateral cingulum is reduced, and there is clearly defined incipient division of the metaconid and metastylid pillars.

<div align="center">MEASUREMENTS</div>

	No. 19764	Archaeo-hippus ultimus No. 1700
Length, anterior side of P_3 to posterior side of M_2...........	60 mm.	....
P_2, approximate anteroposterior diameter..................	16	11.5
P_3, approximate anteroposterior diameter..................	15.8	12
P_3, transverse diameter across hypoconid..................	10.5	9.8
P_4, anteroposterior diameter.............................	15	....
P_4, transverse diameter across hypoconid..................	10.5	....
M_1, greatest anteroposterior diameter.....................	13.6	....
M_1, transverse diameter across protoconid.................	9	....
M_2, greatest anteroposterior diameter.....................	13.6	....
M_2, transverse diameter across protoconid.................	8.5	....

Relationships.—The upper and lower jaw specimens (nos. 19840 and 19764) from the Mohave region resemble each other in a number of important particulars. Their similarity in structure, and their occurrence in the same region give a reasonable assurance that they represent the same type. The two specimens show similarity in the following characters: (1) height of tooth crowns; (2) rugosity of enamel; (3) absence of cingulum on the protocone side; (4) stage of development, as seen in separation of metaconid and metastylid, in increase of size and compression of the protoconule, in complication of the metaloph, and in increase of size in hypostyle. The stage of evolution in the two specimens shows about equal advance beyond the dentition of *Hypohippus*.

As has been suggested for the two specimens considered separately, the form represented by them shows resemblance to *Hypohippus, Archaeohippus, Parahippus,* and *Anchitherium.* It is in general more advanced than *Hypohippus.* Its habit and stage of evolution are near *Archaeohippus,* from which it is distinguished in the upper molariform teeth by absence of cingula on the protocone side, by higher cusps, and by a slightly more advanced stage of development of the protocone and hypostyle, though the metaloph is not more advanced in the Mohave form. From the imperfectly known lower teeth of *Archaeohippus* it is distinguished by the absence of external cingula, and evidently also by proportions of the premolars. The absence of cingula on the protocone side of both

upper and lower molars may have some significance in considering the stage of evolution, or may concern only the matter of immediate relationship.

The Mohave type represented by specimens no. 19840 and 19764 is evidently related to *Parahippus* in most characters, though distant from the typical form. The absence of a crochet in the upper teeth, and the very slight separation of metaconid and metastylid columns in the lower teeth, indicate a relatively undeveloped stage. Whether this form is too primitive to be included in *Parahippus* will be determined most clearly when better material is available for study.

Some significance may attach to the fact that this form, having a certain resemblance to *Parahippus*, but being relatively primitive, occurs in strata which were presumably deposited in a later period than the time of maximum development of the genus *Parahippus*. On the other hand, the Mohave form, being somewhat more advanced than *Archaeohippus* in most respects, and occurring in strata presumably younger, might be considered a product of modification from *Archaeohippus*. It is interesting to note that in the development of the crochet, in which one would expect advance, the Mohave form is more primitive than the Middle Miocene *Archaeohippus*.

The Mohave type strongly suggests *Anchitherium*, from which it seems to be separated by its slightly larger protoconule, separation of metaconid and metastylid columns of the lower teeth, and reduction of the cingulum on the outer side of the lower cheek-teeth and inner side of the upper cheek-teeth. *Anchitherium* is, moreover, doubtfully represented in America. *Anchitherium* (?) *zitteli* of China approaches the Mohave form in certain characters, but seems clearly separable.

The relationships of the interesting form from Mohave seem almost to require the establishment of a distinct group to give to this species such a position in the classification as will clearly indicate its true affinities. It could be assigned tentatively to a place with *Archaeohippus*, as an advanced stage with protoconule and hypostyle more progressive, cingulum of the protocone side absent, and complication of the metaloph not more advanced. It could be referred to *Parahippus*, as a primitive stage with crochet undeveloped, though the metaloph shows secondary folding, and with

metaconid and metastylid in beginning separation. The reference of this form to one of the described genera depends somewhat upon the extent to which the limits of these groups may be expanded by later studies. A reference to *Parahippus* is apparently open to fewer definite objections than a reference to *Archaeohippus*.

Transmitted October 13, 1913

NEW PROTOHIPPINE HORSES FROM TERTIARY BEDS ON THE WESTERN BORDER OF THE MOHAVE DESERT

CONTENTS

INTRODUCTION

INVESTIGATION of the Tertiary mammal-bearing beds in the Mohave Desert, carried on by the Department of Palaeontology of the University of California within the past three years, has brought to light collections of unusual interest in two localities. One station is in the Barstow Syncline, north of Barstow, California, and near the middle of the desert. The other locality is in the El Paso Range on the extreme western border of the desert.

The greater part of the Tertiary mammal collection obtained in the Mohave region has come from exposures in the Barstow Syncline. The fauna obtained in these exposures has been reported by the writer[1] as evidently representing a stage near Upper Miocene. The representatives of the horse group known from the Barstow Syncline include at least three forms: a *Merychippus* of advanced type, near *M. calamarius;* a large form near *Hypohippus;* and a recently described species near *Parahippus.*[2] The association of Equidae, now known from the typical Mohave Beds north of Barstow, seems to bear out the original suggestion that these strata are near Upper Miocene in age.

The fauna from the beds at El Paso Range contains some elements which are quite distinct from those of the Barstow region. Remains of horses are only fairly represented, but such forms as are

[1] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 6, p. 169, 1911.
[2] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, p. 427, 1913.

present seem to represent a different fauna from that found in the Mohave Beds of the Barstow Syncline.

At least two types of horses are known from the beds in the El Paso Range. One group closely approaches the characters of the Old World *Hipparion*, and may include two species. The other type approximates *Protohippus*, and possibly includes two species. It is doubtful whether typical *Merychippus* is represented, and remains of *Hypohippus* and *Parahippus* have not been certainly recognized.

The general aspect of the representatives of the Equidae found in El Paso Range is that of a fauna distinctly later than that of the Barstow Syncline, and approximating very late Miocene or early Pliocene.

HIPPARION(?) MOHAVENSE, n. sp.

Type specimen no. 19787, an upper premolar three with two associated upper cheek-teeth, and several lower teeth presumably from the same individual. From the Ricardo Beds, in the El Paso Range, north of Mohave, California.

Crowns of upper molars nearly straight; protocone small, separate from proto-conule and nearly circular in cross-section; enamel of the fossettes very strongly crinkled; mesostyle of nearly uniform width.

The crowns of the upper molars are nearly straight, or but slightly curved, and not greatly elongated. In the type material (figs. 1*a* to 3*b*), in which the enamel plications are very strong, the length of the crown measures about one and one-half times the transverse diameter. In other specimens, evidently but little worn, the height of upper cheek-tooth crowns may equal about twice the transverse diameter. The transverse diameter of the anterior molars and posterior premolars about equals or slightly exceeds the antero-posterior diameter. The cement layer is well developed on the outer and inner sides. The parastyle and mesostyle are prominent. The external rib formed by the mesostyle is especially strong on the premolars. It narrows very gradually from the base. The middle region of the outer sides of the paracone and metacone crescents is flat, but may show a slight tendency to formation of a median rib.

The small protocone is free almost to the base in most specimens. In cross-section it is nearly circular or is slightly elongated antero-posteriorly. The walls of the anterior and posterior fossettes show unusually numerous plications. The posterior wall of the prefos-sette and the anterior wall of the postfossette are each thrown into

six or more short folds.   The anterior wall of the prefossette also exhibits very marked plications.   The posterior wall of the post-fossette shows at least one strong fold.

The upper cheek-teeth do not closely resemble those of any West-American species known to the writer.   In some respects they show more similarity to *Neohipparion plicatile* of the Florida Pliocene than to most of the western species.   The general form of the teeth, the small, round protocone, the very complexly folded enamel of the
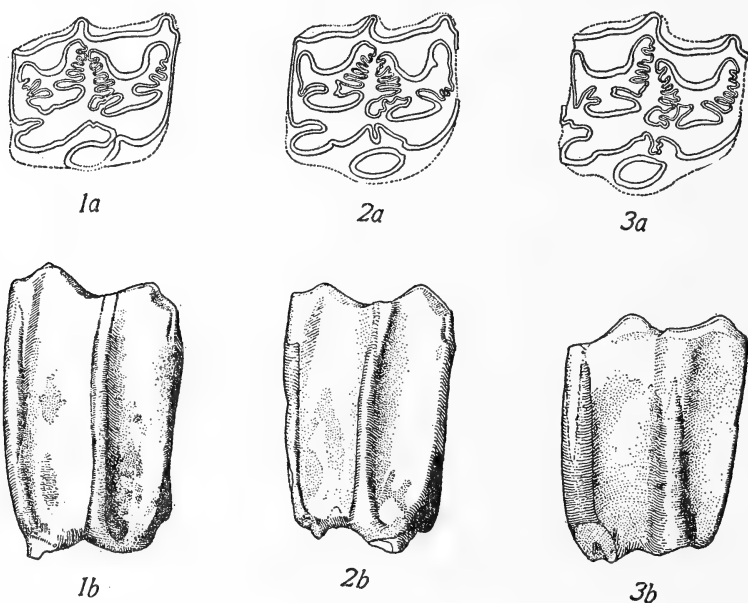
Figs. 1*a* to 3*b*.   *Hipparion*(?) *mohavense*, n. sp.   Upper cheek-teeth.   No. 19787, natural size.   Late Tertiary near Ricardo, California.   Figs. 1*a* and 1*b*, M²; fig. 1*a*, occlusal view; fig. 1*b*, outer view.   Figs. 2*a* and 2*b*, M¹; fig. 2*a*, occlusal view; fig. 2*b*, outer view.   Figs. 3*a* and 3*b*, P³; fig. 3*a*, occlusal view; fig. 3*b*, outer view.

fossettes, and to some extent the detailed pattern of the enamel folds in the Mohave form are strikingly similar to the expression of corresponding characters of the Old World *Hipparion* species.   It may be noted in this connection that the American form *N. plicatile*, with which the Mohave form has been compared, is considered by Gidley[3] as representing a group differing in some respects from other American species and possibly belonging to an American branch of the Old World *Hipparion*.

[3] Gidley, J. W., Bull. Amer. Mus. Nat. Hist., vol. 23, p. 905, 1907.

In dimensions and in general form the Mohave species is very near to *Hipparion richthofeni* of China and to the typical *H. gracile* of Europe. The Mohave form seems distinguishable from *H. gracile* by somewhat larger size, a more distinct tendency to lateral compression of the protocone, slightly wider mesostyle ribs, and possibly by very small differences in the folding of the enamel walls of the fossettes.

The resemblance of *H. mohavense* to *H. richthofeni*, as that species is figured by Schlosser,[4] is very close. In the California form the dimensions, cross-section of protocone, and most details in the enamel pattern match closely the corresponding characters of the Chinese species. There are small differences suggesting separation; as in the tendency of the small fold of the inner enamel wall opposite the protocone to show two or more subdivisions in most specimens of *H. richthofeni*, while in the Mohave specimens the fold is commonly simple; and according to the measurements given by Schlosser there is a suggestion that the upper molars of *H. richthofeni* are slightly longer than in the Mohave species.

The Mohave form differs from *Hippodactylus antilopinum* of India in the more clearly rounded enamel folds, and the longer enamel fold on the inner wall opposite the protocone. It differs from *Hipparion theoboldi* in its smaller size.

Several lower cheek-teeth associated with the upper teeth constituting the type specimen of *Hipparion mohavense* are presumably a part of the type specimen. The lower teeth are long-crowned, but do not appear to have been unusually long previous to wear. The antero-internal column formed by the metaconid and metastylid is long anteroposteriorly, and is divided on the medial side by a deep, wide longitudinal furrow. The enamel folds show a tendency to form secondary plications, especially on the inner side of the parastylid ridge, and on the anterior side of the hypoconid pillar. The small, sharp fold common on the antero-external angle of the protoconid is seen in several specimens.

The form of the lower teeth is near that of certain of the specimens of *Hipparion richthofeni* figured by Schlosser[5] and by Koken.[6] The enamel folds in *H. richthofeni* are possibly a little more pronounced,

[4] Schlosser, M., Säugethiere Chinas, Abh. Munich Akad., Math-Ph. Classe, Bd. 22, Taf. 4, 1903–6.

[5] *Op. cit.*, Taf. 4.

[6] Koken, E., Palae. Abh., Bd. 3, Taf. 4, 1885.

and the crowns a little longer, but the discernible difference appears small.

An upper cheek-tooth closely resembling the Mohave species is known from the Coast Range region of California. This specimen was recently referred to *Hipparion* or *Neohipparion* by the writer.[7] It is interesting to note that a suggestion of relationship of this tooth to *Hipparion richthofeni* was made by Gidley in correspondence in 1904. The tooth had, however, been labeled *Neohipparion*, and the recent reference to *Hipparion* by the writer was presumed at the time the determination was made to be at variance with that expressed by Gidley.

MEASUREMENTS OF No. 19787

	P^3	M^1	M^2
Anteroposterior diameter	22 mm.	21.4	21.6
Transverse diameter	23	22	20
Height of crown	32+	32+	37

HIPPARION(?), sp.

Two moderately worn premolars (no. 19770) representing a *Hipparion* form somewhat larger than the type of *H. mohavense* show enamel folds bordering the fossettes in general like those of *H. mohavense*, but less pronounced and more simple. The difference does not appear to be due entirely to age, and this form may represent a species of *Hipparion* distinct from *H. mohavense*.

A P^2 (no. 19438) may be the same as *H. mohavense* or may be a distinct species. The enamel plications seem less complex than in *H. mohavense* and are more acute.

MEASUREMENTS

No. 19770
    P^4, anteroposterior diameter................................... 25.5 mm.
    P^4, transverse diameter....................................... 24
    P^4, height of crown.. 30
No. 19438
    P^2, anteroposterior diameter................................... 26
    P^2, transverse diameter....................................... 20.7
    P^2, height of crown.. 30

PROTOHIPPUS(?) TANTALUS, n. sp.

Two large upper cheek-teeth (nos. 19434 and 21221) from the El Paso Range differ from the *Hipparion* forms in the united proto-

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[7] Merriam, J. C., Univ. Calif. Publ. Bull. Dept. Geol., vol. 7, p. 376, and figs. 3a and 3b, p. 375, 1913.

cone and protoconule, curved crown, and large wide fossettes with crinkling of the enamel limited to their adjacent borders. The outer styles are heavy and narrow noticeably above the base (figs. 4a and 4b).

These specimens seem certainly different from any referred to *Hipparion mohavense* or allied species. They possibly represent a type related to *Neohipparion*, but are probably to be included in
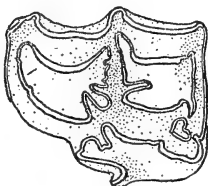
4a
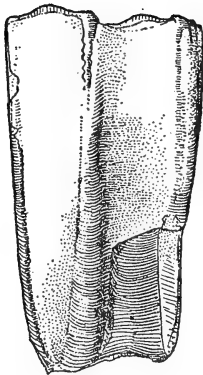
4b

FIGS. 4a AND 4b. *Protohippus*(?) *tantalus*, n. sp. P4(?). No. 19434, natural size. Late Tertiary near Ricardo, California. Fig. 4a, occlusal view; fig. 4b, outer view.

Protohippus or *Pliohippus*. Several much worn upper molars from the Ricardo region seem clearly of an advanced *Protohippus* or *Pliohippus* type, and may represent the same species as the type of *P. tantalus*.

MEASUREMENTS OF No. 19434

P4?, anteroposterior diameter... 24.8 mm.
P4?, transverse diameter... 24
P4?, height of crown... 48

Transmitted December 15, 1913

TERTIARY MAMMALIAN FAUNAS OF THE MOHAVE DESERT

CONTENTS

INTRODUCTION

EARLY in the spring in 1911, John R. Suman, then a student of the University of California, brought to the writer a small collection of fossil bones and teeth obtained on the Mohave Desert by H. S. Mourning of Los Angeles. This collection was presented to the University by Mr. Mourning and Mr. Suman, and constituted the basis for the first study of the Mohave faunas. In a brief article[1] published soon after receiving this collection, the writer called attention to the importance of this discovery, as it offered the possibility of correlating the deposits of the Mohave region with those of the extensive mammal-bearing formations of the Great Plains area, and might ultimately assist in determining the time relations of formations in the Pacific Coast province to deposits of the Great Basin and Great Plains areas. The collection was considered to represent approximately an upper Miocene stage, and to point toward close faunal relation of the Mohave region with the Great Plains area in the period during which this fauna flourished.

In the spring and early summer of 1911, C. L. Baker, then fellow in palaeontology at the University, visited the locality reported by

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[1] Merriam, J. C., A Collection of Mammalian Remains from Tertiary Beds on the Mohave Desert, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 163–169, pl. 29, 1911.

FIG. 1.   Outline map illustrating occurrences of Miocene and Pliocene mammal faunas in Tertiary provinces of the United States west of the Wasatch Range.   B, Barstow beds; Rc, Ricardo beds; C, Chanac formation; ET, Etchegoin-Tulare beds and Merychippus zone; Or, Orinda beds; E, Esmeralda beds; CM, Cedar Mountain beds; T, Truckee beds; MK, McKnight Miocene; V–T, Virgin Valley and Thousand Creek beds; I, Idaho beds; Ir, Ironside Pliocene; Rt, Rattlesnake Pliocene and Mascall Miocene; El, Ellensburg formation.

Mr. Mourning and secured a considerable collection of mammalian remains. Mr. Baker was joined later by Wallace Gordon and by Mr. Suman, who assisted with the work. In connection with the palaeontologic study it was necessary to make a geological reconnaissance of the formations concerned. The results of this investigation have already been published by Mr. Baker.[2]

In December, 1911, a second expedition under the charge of Mr. Baker visited exposures of Tertiary beds near El Paso Peak on the northwestern border of the Mohave Desert, and made further collections, which added considerably to the list of forms obtained by the preceding expedition. On the December, 1911, expedition, the party with Mr. Baker consisted of J. Guintyllo, S. H. Gester, and G. E. Stone. The geologic section of the region near El Paso Peak has been described by Mr. Baker[3] with the results of his work on the correlation of events in the physical history of the region.

In January, 1913, H. S. Mourning and J. P. Buwalda visited the exposures of Tertiary mammal-bearing beds in the area north of Barstow, and obtained an excellent collection of the fauna at localities previously visited by Mr. Mourning. This collection was supplemented by specimens purchased from Mr. Mourning, and by some very useful material which Mr. Mourning kindly presented to the University.

In December, 1913, and January, 1914, J. P. Buwalda, assisted by E. R. Brainard, E. M. Butterworth, and C. Stock, made a further examination of the Tertiary beds in the region of the El Paso Range in the northwestern part of the Mohave region, and obtained a collection of mammalian remains which adds much to our knowledge of the fauna of this section.

In March, 1915, the Pliocene beds west of the town of Mohave and at the type locality of the Ricardo beds west of the El Paso Range were visited by J. P. Buwalda and the writer. On this excursion a number of important specimens were secured from the lower portion of the Ricardo section at the type locality.

[2] Baker, C. L., Notes on the Later Cenozoic History of the Mohave Desert Region in Southeastern California, Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 333–383, pls. 34–43, 1911.

[3] Baker, C. L., Physiography and structure of the Western El Paso Range and the Southern Sierra Nevada, Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 117–142, pls. 8–10, 1912.

In the summer of 1915, a party working under direction of J. P. Buwalda worked over exposures of the Ricardo in the El Paso Range and secured a very valuable representation of the mammalian fauna of these beds.   In addition to Dr. Buwalda this party included C. L. Moody, Edward Thatcher, and J. M. Douglas.

GEOGRAPHIC SITUATION AND EXISTING PHYSICAL CONDITIONS IN THE MOHAVE AREA

The Mohave area is a province or subdivision of the Great Basin region, of which it forms the southwest corner.   The Great Basin is separated from the Coast or Pacific region on the northwest side of the Mohave area by the abruptly rising Sierra and Tehachapi ranges.   On the southwest side of the Mohave, the San Bernardino, San Gabriel, and other ranges extending between the San Gabriel and the Tehachapi, form a clearly marked boundary.

To the north the Mohave area extends into valleys between the parallel ranges situated to the east of Owens Lake.   To the northeast it grades almost insensibly into the Middle Basin or Nevada area of the Great Basin.   A natural boundary seems to be fixed by a range running nearly parallel with the California-Nevada line southeast of the Amargosa Range.   To the east the Mohave area may be limited by more or less irregular groups of mountain ranges lying between the San Bernardino Range and the Opal Mountains and Dead Mountains west of the Colorado River at the southern end of Nevada.   Considering this area in a broad sense, rather than as limited strictly to the Mohave Desert, the Mohave area seems naturally to reach east and southeast to the western border of the plateau, lying to the east of the Colorado River.

The Mohave area is in general one of extreme aridity at the present time.   The rainfall is about five inches in the western portion of the desert near the town of Mohave, and may be one or two inches less in the region farther to the east, near Barstow.   Living streams are rare, and travel in all of this region has necessarily been limited by scarcity of localities at which potable water can be obtained.   In recent years the development of artesian water has made agricultural operations possible in regions which previously had been uninhabitable.

EXISTING LIFE OF THE MOHAVE AREA

The vegetation of the Mohave area is at the present time limited to desert types, and the contrast with the flora on the opposite side of the mountains bordering the desert to the west is marked. Plants of arboreal types comprise only a very few junipers and the tree yuccas. The creosote bush is commonly present and is the dominant plant of this area.

The Recent mammalian fauna of the desert includes thirty-five species, of which twenty-one are rodents. The Ungulata include only the pronghorn antelope (*Antilocopra americana*) and the desert bighorn (*Ovis nelsoni*). The Carnivora include the desert coyote (*Canis ochropus estor*), the Mohave Desert kit fox (*Vulpes macrotis arsipus*), the California raccoon (*Procyon lotor psora*), a spotted skunk, a striped skunk, the northwestern cougar (*Felis oregonensis*), and the desert wildcat (*Lynx eremicus eremicus*). The rodent fauna comprises thirteen genera which are included in the representative list given below, kindly furnished for this study by Dr. Joseph Grinnell.

RECENT MAMMALS KNOWN FROM THE MOHAVE DESERT

Myotis californicus pallidus Stephens	Little pallid bat
Pipistrellus hesperus hesperus (H. Allen)	Western bat
Eptesicus fuscus (Beauvois)	Large brown bat
Antrozous pallidus (LeConte)	Desert pallid bat
Nyctinomus mexicanus Saussure	Mexican free-tailed bat
Canis ochropus estor C. H. Merriam	Desert coyote
Vulpes macrotis arsipus Elliot	Mohave Desert kit fox
Procyon lotor psora Gray	California raccoon
Spilogale phenax C. H. Merriam	California spotted skunk
Mephitis occidentalis holzneri Mearns	Southern California striped skunk
Felis oregonensis Rafinesque	Northwestern cougar
Lynx eremicus eremicus Mearns	Desert wildcat
Onychomys torridus pulcher (Coves)	Desert grasshopper mouse
Reithrodontomys megalotis deserti Allen	Desert harvest mouse
Peromyscus maniculatus sonoriensis (LeConte)	Sonora white-footed mouse
Peromyscus crinitus stephensi Mearns	Stephens Cañon mouse
Neotoma intermedia desertorum C. H. Merriam	Desert wood rat
Neotoma fuscipes mohavensis Elliot	Mohave wood rat
Microtis californicus mohavensis Kellogg	Mohave River meadow mouse
Thomomys perpallidus perpes Merriam	Lone pine pocket gopher

Perognathus panamintinus bangsi Mearns	Bangs pocket mouse
Perognathus formosus C. H. Merriam	Long-tailed pocket mouse
Perognathus penicillatus stephensi C. H. Merriam	Stephens pocket mouse
Perognathus fallax pallidus Mearns	Pallid short-eared pocket mouse
Perodipus microps C. H. Merriam	Small-faced kangaroo rat
Perodipus panamintinus C. H. Merriam	Panamint kangaroo rat
Dipodomys deserti Stephens	Big desert kangaroo rat
Dipodomys merriami simiolus Rhoads	Allied kangaroo rat
Citellus beecheyi fisheri (C. H. Merriam)	Fisher ground squirrel
Citellus mohavensis (C. H. Merriam)	Mohave ground squirrel
Ammospermophilus leucurus leucurus (C. H. Merriam)	Antelope ground squirrel
Lepus californicus deserticola Mearns	Colorado Desert jackrabbit
Sylvilagus auduboni arizonae (Allen)	Arizona cottontail
Antilocapra americana (Ord)	Pronghorn antelope
Ovis nelsoni C. H. Merriam	Desert bighorn

Of the Recent fauna only a few genera are known from the Tertiary of the Mohave area. A number of the existing forms, such as the bighorn, are probably immigrants from the Old World, which arrived considerably later than the deposition of the youngest Tertiary beds of the Mohave. Unfortunately we have as yet been able to obtain only a very meager representation of the rodent fauna of the Tertiary beds of this region. When this fauna is better known a number of genera now living will undoubtedly be recognized in the Mohave Tertiary.

OCCURRENCE AND NOMENCLATURE OF THE MAMMAL BEDS

Geologic sections of the Tertiary beds in the Mohave region are most satisfactorily exposed in an extensive series of deposits in the Barstow syncline north of the town of Barstow, and in excellent exposures around Ricardo Post Office in Red Rock Cañon, between the eastern foot of the Sierras and the El Paso Range. These deposits, with other exposures spread widely over this area, have been referred by C. L. Baker,[4] and earlier in part by O. H. Hershey,[5] to the Rosamond Series on the assumption that they represent one great period of accumulation.

[4] Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, pp. 333–383, 1911.
[5] Amer. Geol., vol. 29, pp. 365–370, 1902.

While the name Rosamond may be used tentatively for the middle and late Tertiary sediments of the Mohave area it has not been demonstrated that the several formations represented are as closely related in their depositional history as they appeared in the first investigations.   It seems necessary to discuss the beds in the Barstow syncline and those at Ricardo as distinct divisions, since the evidence of the faunas indicates that the deposits were laid down in rather widely separated epochs.   The known fauna of the Barstow syncline occurs near the top of the section, and it is very doubtful whether beds containing a fauna like that of the much more advanced stage of Ricardo are present in the Barstow section. The fauna at Ricardo occurs through the greater part of the Red Rock Cañon section.   Though it is possible that the lower Ricardo beds contain a faunal assemblage similar to that of the Barstow region, evidence indicating the presence of a typical Barstow fauna has not been obtained.   The Rosamond series of Hershey may include beds containing the older fauna of Barstow, but it is doubtful whether it comprises sediments of the stage represented at Ricardo.

In an earlier publication the writer[6] referred to the fauna of the Barstow syncline as the Mohave fauna, this name being considered mainly as a geographic designation.   Later, in order to avoid confusion with other Tertiary faunas occurring in the Mohave area, the name Barstow[7] has been used for this faunal assemblage, and Barstow formation[8] for the beds containing the Upper Miocene or Barstow fauna.   This formation comprises the uppermost of five divisions in the Barstow syncline, described by Baker[9] as the Fossiliferous Tuff member, and any other beds which may be recognized as representing the horizontal or vertical extension of the same depositional unit.   The limits of the Barstow formation may be found to correspond with those of the Fossiliferous Tuff member, or they may include a greater range of sediments above and below.   It is possible that the Barstow fauna occurs in all of the strata of the Barstow syncline.   It is also easily possible that

[6] Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 168, 1911.
[7] Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, p. 285, 1915; vol. 9, pp. 7, 49, 1915; vol. 9, p. 171, 1916.
[8] Merriam, J. C., Pop. Sci. Mon., p. 252, March, 1915.
[9] *Op. cit.*, vol. 6, pp. 345–346, 1911.

the lowest strata of that section will be discovered to contain a faunal assemblage much older than the particular Upper Miocene assemblage known in the Fossiliferous Tuff.   The Resistant Breccia member immediately below the Fossiliferous Tuff in Baker's Barstow syncline section seems to contain a representation of the Barstow fauna, and may ultimately be included in the Barstow formation.   Should the Resistant Breccia be recognized as a distinct formation the name Barstow group may be used for the sequence of formations.

The Barstow formation will be recognized as a division of the Rosamond Series if the Barstow syncline corresponds to the type section of the Rosamond at Rosamond station, as has been assumed by Hershey and by Baker.   As yet it seems difficult to make certain of correlation between the Barstow syncline and the type Rosamond section, as palaeontologic evidence is lacking at Rosamond.   If the Barstow formation is considered as a member of the Rosamond, it is presumably a late member of the series.

The section of deposits at Red Rock Cañon was first described by G. K. Gilbert,[10] who gave the essential features of the stratigraphic succession and referred to the exposures as the Red Rock Cañon beds.   More than twenty years later, in 1896, H. W. Fairbanks[11] gave a further description of the section at Red Rock Cañon furnishing estimates of thickness, degree of deformation, and extent of distribution of the beds.   Following the usage of Gilbert, Fairbanks referred to the section as the Red Rock Cañon beds.

In a paper reviewing the Eocene of North America in 1900, J. H. Smith[12] used the heading "Mohave Formation" for a paragraph which, with the exception of a little more than one line, consisted of a quotation from Fairbanks' description of the sediments in the region of El Paso Range and Black Mountain. Smith's reference was directed especially toward a portion of the section near Black Mountain from which Fairbanks reported leaves determined by F. H. Knowlton as Eocene.   Recent investigation of the area in which the leaves were found has not made clear the stratigraphic relations of the plant horizon, and it is possible that

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[10] Geographical and Geological Explorations West of the 100th Meridian, pp. 142–143, 1875.

[11] Amer. Geol., vol. 17, pp. 68–69, 1896.

[12] Jour. Geol., vol. 8, pp. 455–456, 1900.

the lowest beds at Black Mountain from which the reported Eocene leaves were obtained may actually represent an Eocene horizon.

In discussing the Cenozoic history of the Mohave Desert in 1911 C. L. Baker[13] referred the Red Rock Cañon section to the Rosamond Series. In his paper[14] on the Physiography and Structure of the Western El Paso Range Baker continued use of the term Rosamond Series for the Red Rock Cañon section.

Following the discovery that the fauna from the beds in Red Rock Cañon is sharply distinct from that in the Barstow section, the writer has described numerous mammalian forms from the Red Rock Cañon section as representing the Ricardo fauna,[15] Ricardo beds, or Ricardo Pliocene. In a recent article[16] the name Ricardo formation was used for the stratigraphic unit containing the fauna of the beds at Ricardo Post Office.

In some respects there may be justification for use of the name Red Rock Cañon beds, formation, or group for the stratigraphic sequence containing the fauna at Ricardo, as this was the first designation used for the section. The name was however not used for nomenclature purposes either by Gilbert or by Fairbanks, and has the disadvantage of extreme length, including as it does three words. The term Mohave formation occurring in Smith's article is again evidently not applied for naming purposes, as it is merely a heading for a division of the paper, with other names a considerable proportion of which are not actually formations. The application of the name is not clear, as it may be presumed to refer to Eocene beds, and an Eocene formation distinct from the Ricardo group is possibly present in the Black Mountain region. Use of the name Mohave, if it were now adequately defined, would certainly lead to confusion of the fauna at Red Rock Cañon with the Barstow fauna known from the large exposures in the middle of the Mohave Desert. It has therefore seemed necessary to continue use of the name Ricardo for the fauna occurring in the Red Rock Cañon section. In the geologic sense the name Ricardo group may be used for the sequence of strata exposed at Ricardo Post Office

[13] Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 354, 1911.

[14] Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 117–142, 1912.

[15] Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 285, 1913; vol. 7, p. 436, 1913; vol. 8, p. 276, 1914; vol. 8, p. 285, 1915; vol. 9, p. 5, 1915; vol. 9, p. 54, 1915; vol. 9, pp. 170–171, 1916.

[16] Merriam, J. C., Pop. Sci. Mon., vol. 86, p. 253, March, 1915.

with its upward and downward extension within the depositional unit.   It is not improbable that several formations may ultimately be mapped within the limits of the Ricardo group.   The strati- graphic relation of the Ricardo to the Barstow is not determined, as the two are not known to be in contact.   Should the two faunas be found to overlap, the stratigraphic units would perhaps be com- bined, but distinctness of the faunas makes this improbable.

GEOLOGIC RELATIONS OF THE TERTIARY FORMATIONS

The Tertiary sediments of the Mohave area rest upon a base- ment including granites and schists of pre-Tertiary age, and extru- sive igneous rocks presumably at least as old as Lower Miocene. A flow of basic andesite or of acid basalt overlies the granitic rocks and underlies the basal Tertiary sediments of the Barstow syncline. A rhyolite described by Lindgren from the Calico Mountains is stated by Baker to underlie beds considered to represent the Rosa- mond Series.

Excepting marine deposits of Eocene age, the oldest Tertiary rocks in the Mohave area of which the age is certainly known are included in the Barstow formation representing the upper Miocene. The Barstow fauna is found in the uppermost or Fossiliferous Tuff member of the five divisions referred by C. L. Baker to the Rosa- mond Series in the section north of Barstow.   The Resistant Brec- cia member immediately below the Fossiliferous Tuff member of Baker's section also contains mammalian remains presumably of the same faunal stage as those of the member immediately above. The only known fossil remains occurring below the Resistant Breccia member in the Barstow syncline section consist of a single imperfectly preserved fresh-water gastropod found in the third member from the upper end of the section.   This specimen does not furnish definite evidence of age of the beds in which it occurs.

Leaves stated by F. H. Knowlton to resemble Eocene species were collected by H. W. Fairbanks[17] near the base of the Ricardo section at Black Mountain near El Paso Range on the western border of the Mohave area.   There is some doubt as to the age of these specimens, as also regarding their occurrence, and recent

[17] Amer. Geol., vol. 17, pp. 63–74, 1893.

examination of the old coal workings from which the plants were obtained has not furnished sufficient information to permit a judgment as to the age of the plant-bearing beds.

Dr. Fairbanks reported the occurrence of a seam of coal fourteen inches thick, enclosed between clay strata, and apparently occupying a position below the tuffs to the southeast of Black Mountain. Impressions of leaves in the clay above the coal were examined by Dr. Knowlton who reported that they represent three small fragments of plants belonging in two species, *Sapindus affinis* Newb. and *Anemia subcretacea* (Sap.) Ett. and Bard. This material was considered as hardly sufficient to warrant speaking with positiveness concerning the age of the beds, but the species were considered as certainly Tertiary and seemed to belong to the Eocene. Both species were stated to have quite a wide geographic distribution and with several unimportant exceptions to be confined to the Eocene.

At the writer's request the old coal workings on Black Mountain were recently examined by J. P. Buwalda who reports upon them as follows:

> The location of the old coal workings is about two miles to the southeast of Black Mountain, and in the saddle between that mountain and the main El Paso Range. The coal mines were worked at least 12 or 15 years ago. There is only one shaft available and that can no longer be entered. The coal seen in this locality is at the base of the sedimentary series. The Ricardo here lies on a metamorphosed complex quite certainly of pre-Cretaceous age. It is not possible to say certainly that the leaf formation is a member of the Ricardo formation. It might be a freshwater formation deposited upon the metamorphosed complex of the El Paso Range in early Tertiary time, and the Ricardo beds may be of later date deposited unconformably upon it. The stratigraphic relations around the coal mine are not clear.

> The dump from the coal mine has been burned over so that no solid material is left. A few impressions of two or three plants resembling rushes were found but no determinable specimens were obtained.

Near the extreme western border of the Mohave Desert area the Eocene is represented by marine deposits of the Martinez or Lower Eocene stage.[18a] This section has an estimated thickness of at least 5000 feet. How far the marine Eocene deposits extended over the Mohave area originally is not known. It is possible that

[18a] Dickerson, R. E., Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, p. 293, 1914.

land or fresh-water beds were accumulating in this area contemporaneously with the marine Eocene, or the sea may have covered a considerable portion of the area. No marine deposits of later age than Eocene are known in the Mohave area.[18b]

Barstow Syncline Section.—The section in the Barstow syncline consists in a large part of volcanic materials with beds of clay and shale at some horizons. The deposits are evidently partly of terrestrial and partly of lacustrine origin. At rare horizons, remains of fresh water mollusca including *Planorbis* and *Anodonta*(?) are abundant. In other beds scattered and weathered bones, representing a large tortoise and numerous mammals belonging to the open plains type probably indicate accumulation on dry land. Baker held that the Rosamond as described by him was accumulated mainly "under the same conditions of desert aggradation as operate in the region at the present day." As is suggested in the following discussion (p. 1128) the writer considers that during deposition of the Barstow beds the climate may have been considerably more humid than at the present time.

The Barstow syncline section was divided by Baker into the following five members:

    1. Fossiliferous tuff member (uppermost division).
    2. Resistant breccia member.
    3. Fine ashy and shaly tuff member.
    4. Tuff-breccia member.
    5. Basal breccia member (lowest division).

The five divisions in the Barstow syncline were considered by Baker to represent to some extent local conditions, the number of members being possibly increased or diminished at other localities in this area. It is perhaps desirable to give a distinct formation name to each of the five divisions, but a more intimate knowledge of the geology of this region must be obtained before the divisions are all recognized as representing more than local phases of the series. A more complicated history for the beds of this section than that now known may yet be demonstrated.

The lowest or Basal Breccia member in the south limb of the Barstow Syncline rests upon the eroded surface of both granodiorite

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[18b] Since this paper was written Wallace Gordon has discovered marine beds of middle Tertiary age on the western border of the Mohave area near Quail Lake, 35 to 40 miles west of Lancaster on the main line of the Southern Pacific Railroad.

and a basic andesite or acid basalt. The Basal Breccia contains fragments of the rocks below it. The fragments are mostly angular or subangular. The rocks of this member evidently represent a type recently designated as fanglomerate by A. C. Lawson.[19] This division is at least several hundred feet in thickness.

The Tuff-Breccia member, or second division from the base, differs from the lowest member in being composed of finer fragments containing less granitic material and in having a much larger proportion of volcanic ash in the matrix. It is considerably over a thousand feet in thickness in the north limb of the Barstow syncline. The upper limit of this member was considered by Baker to be defined by an unconformity of unknown extent. This division is made up of variegated beds ranging from cream-color through red, purple, brown, and green.
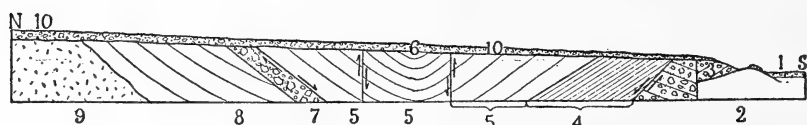
FIG. 2. North and south section through the middle of the minor axis of the Barstow syncline. Length of section is approximately three miles. (1) Basin alluvium. (2) Basic andesite or acid basalt. (3) Basal breccia member. (4) Fine ashy and shaly tuff member. (5) Resistant breccia member. (6) Uppermost beds of fossiliferous tuff member. (7) Coarse granodiorite breccia, separated from (8) by an unconformity. (8) Tuff-breccia member. (9) Granodiorite. (10) Unconformable mantle of alluvial debris, dipping toward basin. (After Baker.)

The Fine Ashy and Shaly Tuff member, numbered three above the base, has a thickness of approximately 500 feet. It consists of fine materials comprising ash toward the base, and dark, compact mud-stone toward the top. A single fossil, a *Planorbis*, was found in this division.

The Resistant Breccia member, number four, may be designated as a fanglomerate. It is in general coarser than the Tuff-Breccia. It differs from the basal member in having a larger percentage of volcanic ash. It weathers into badland forms, and contributes some of the characteristic scenic features of the region. This division is approximately 1000 feet in thickness. The beds range in

[19] Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 325–334, 1913.

color from gray to brown and red, but are not as brilliantly colored as in the Tuff-Breccia member.   A considerable collection of mammalian remains was obtained in this division.   These specimens seem to represent the fauna known from the typical horizon of the Barstow in the fifth division immediately above.

Of the Fossiliferous Tuff member, the typical Barstow, forming the uppermost portion of the section, evidently only a portion is now available for study, the remainder having been removed by erosion.   There is a gradual gradation from the coarser beds of the Resistant Breccia member into the fine, overlying beds of the Fossiliferous Tuff.   The uppermost division is made up mainly of bluish-gray to yellowish-brown, slightly indurated strata, composed largely of fine arkose with a considerable percentage of volcanic ash.   The principal deposits of mammalian remains representing the Barstow fauna occur in this member of the Barstow syncline section.

Ricardo or Red Rock Cañon Section.—In the extensive exposures of sediments constituting the type section of the Ricardo group at Red Rock Cañon between the El Paso Range and the Sierra Nevada, the mammalian fauna is distinctly different from that of the Barstow syncline, and of a later phase.   This section includes more than three thousand feet of deposits which are largely tuffaceous. The section as given by Baker is as follows:

	Feet
Brownish to red tuff-breccia............................	...
Ashy, tuffaceous beds, quite coarse and poorly assorted up to	75
Fine, well cemented breccia............................	40
Arkose and lava-breccia interbedded with tuff............	...
Vesicular basalt.......................................	...
Tuff-breccia, fine, gray, poorly stratified................	50
Vesicular basalt.......................................	50
Tuff-breccia, light gray, rather fine, poorly stratified.......	300
Gray beds interspersed with layers of dark red............	150–250
Pink-spotted tuff-breccia forming one massive bed........	100
Dark, red breccia with thinner interstratified gray layers...	250+

Dr. J. P. Buwalda, who has made a careful study of the type section of Ricardo, giving special attention to the highest and lowest portions, has kindly furnished the following description and measurements:

ESTIMATED SECTION OF THE STRATA EXPOSED ALONG RED ROCK CAÑON
NEAR RICARDO

Feet

Extending from the upper of the basalt flows to the top of the
exposed section. Beds of yellowish arkosic material, consist-
ing of coarse angular particles of quartz and feldspar and
containing a large admixture of angular fragments of granitic
rock; muddy sandstones gray, light bluish gray or brown in
color and which because of lack of classification of their ma-
terials are indistinctly bedded; occasional layers of ash, pumi-
ceous material, and brown calcareous material. The general
lack of classification and of distinct bedding in the materials
and their angular character indicate that they are quite cer-
tainly waste-slope and playa lake deposits................. 1350 ?
Columnar basalt, vesicular at upper surface................... 25 ?
Grayish blue arkosic strata, with some clay layers............ 40 ?
Of the section beneath the lavas the lower portion consists prin-
cipally of bluish arkosic material, the middle portion of tuf-
faceous strata including several hundred feet of massive pu-
miceous tuffs of pink and brown hues, and the upper portion,
immediately beneath the lava, consists principally of bluish
arkosic beds with some clayey material.................... 1400 ?

Mammalian remains are found through the whole of the Ricardo
section. At a number of horizons, both above and below the lavas,
specimens have been found relatively abundant. It is possible that
further collecting along the strike of the beds will disclose other
localities in which material will be found well represented at hori-
zons from which as yet little has been obtained.

PALAEONTOLOGIC MATERIALS AVAILABLE

Remains of Tertiary vertebrates are known from a wide area in
the Mohave region. They are not abundant in many places, but
at a few localities fragmentary specimens are found scattered over
the ground in considerable numbers. Connected parts of skeletons
are rare. At a number of points where bones were found in place
in the Tertiary sediments they were disconnected, and it is evident
that the mode of deposition of the beds, and of the accumulation of
remains, were such that skeletal parts were generally widely scat-
tered and broken or weathered before final burial.

The preservation of teeth and bones available is commonly good;
that is, the bones have not rotted nor broken down to a great ex-
tent since burial.

The collections obtained represent several thousand specimens, mostly teeth and portions of limb bones.   In a few cases good skull material was secured.

In the Barstow beds vertebrate remains are found almost exclusively in the uppermost zone of the Barstow syncline as described by Baker.   This division of the section was designated by Baker[20] as the Fossiliferous Tuff member.   In this portion of the section there are occasional layers several inches in thickness containing an unusually large representation of mammalian bones.   One horizon of this nature furnishing many remains of *Merychippus* was known in the field as the Merychippus bed or zone.   Bones were found in the Resistant Tuff member or fourth horizon, but were not discovered, so far as the writer is aware, in the first, second, and
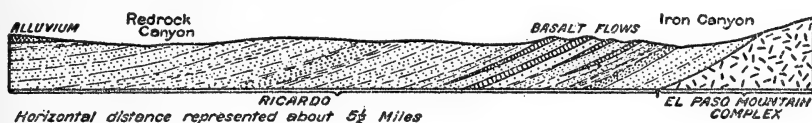
Fig. 3.   Somewhat generalized north and south section through the Ricardo beds, extending from the basement complex of El Paso Mountain to the alluvium of the Mohave Desert. Section prepared by J. P. Buwalda.

third of the five members, counting upward from the base of the section.

In the Ricardo beds mammalian remains were found through the greater part of the section.   Good specimens are not abundant at any horizon, but at a few localities fragments are common.   At nearly all horizons careful collecting will uncover a small representation of the fauna.

BARSTOW FAUNA

Mollusca
  Anodonta?
  Planorbis mohavensis Hannibal
  Limnaea, sp.
Testudinata
  Testudo mohavense, n. sp.
Aves
  Buteo, sp.

Carnivora
  Canid (Canis?), sp. small
  Tephrocyon, near temerarius (Leidy)
  Aelurodon, near wheelerianus Cope
  Aelurodon, Dinocyon, or Amphicyon,
    sp.
  Machaerodont, sp. *a*
  Machaerodont, sp. *b*

[20] Baker, C. L., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 345, 1911.

Machaerodont, sp. *c*

Felid?, indet.

Pseudaelurus, sp.

Rodentia

Lepus?, sp.

Proboscidea

Tetrabelodon?, sp.

Equidae

Hypohippus, near affinis (Leidy)

Parahippus? mourningi Merriam

Merychippus (Protohippus) inter-
montanus Merriam

Merychippus calamarius stylodon-
tus, n. var.

Merychippus sumani Merriam

Protohippus? or Pliohippus?, sp.

Suidae

Prosthennops?, sp.

Oreodontidae

Merycochoerus? buwaldi, n. sp.

Camelidae

Procamelus, sp. *a*

Procamelus, sp. *b*

Pliauchenia, sp.

Alticamelus?, sp.

Cervidae

Dromomeryx or Cervus?, sp.

Bovidae

Merycodus necatus? Leidy

Merycodus? coronatus Merriam

RELATION OF THE BARSTOW FAUNA TO ITS ENVIRONMENT

The fauna of the Barstow beds is as a whole that of an open country affording fairly abundant grass and herbage, and evidently better watered than the Mohave Desert at the present day. The abundance of remains of grazing horses of the *Merychippus* type, the presence of mastodons, oreodonts, abundant merycodonts, a considerable variety of camels, and a peccary all indicate that nutritious vegetation must have been more abundant than at present. The *Merychippus* forms would probably not have been present in such numbers unless grasses were well represented.

The climate of the Mohave area during the time of deposition of these mammal-bearing beds was not improbably semi-arid, like portions of the Great Valley of California at the present day. The relatively small representation of peccaries and oreodonts and of the *Hypohippus* group, and the presence of large tortoises is possibly to be correlated with open semi-arid character of the country.

That small bodies of water were present at times in this area is shown by the discovery of an abundance of fresh-water molluscan remains at certain horizons.

STAGE OF EVOLUTION AND RELATIONSHIPS OF THE BARSTOW FAUNA

RELATION TO TERTIARY FAUNAS OF THE GREAT BASIN REGION

The fauna of the Barstow beds represents a stage in the evolution of Tertiary mammalian faunas not previously distinctly recognized in the Great Basin Province. It seems clearly later than the

Middle Miocene stage of the Mascall and Virgin Valley; and is markedly older than Rattlesnake, Thousand Creek, and Ricardo, representing the next known stage following the Middle Miocene in the Great Basin.   The fauna of the Barstow has few if any species in common with that of the Ricardo, and is of a distinctly older type.   Its nearest relationships are with the faunal assemblage of the Cedar Mountain region of southwestern Nevada, from which it possibly differs somewhat in stage.

Compared with the Middle Miocene faunas of the Mascall and Virgin Valley the Carnivora of the Barstow fauna show a more progressive stage.   Large aelurodons are common, though *Tephrocyon*, a characteristic genus of the Great Basin Middle Miocene, is also well represented.   *Aelurodon* is only doubtfully represented in the Middle Miocene.   Among the ungulates *Hypohippus* is represented by a larger species than that of the Virgin Valley.   The abundantly represented *Merychippus* is of a larger type, with longer-crowned cheek-teeth than that of the Mascall and Virgin Valley, and grades into forms which are difficult to exclude from *Protohippus*.   Though such advanced forms as *Pliohippus* and *Hipparion* are reported from the Mascall no remains of either of these genera are certainly known from that formation.   Some of the species previously listed from the Mascall have been obtained in the Rattlesnake by University of California parties.   In the Virgin Valley beds, with a fauna similar to that of the Mascall, there is no suggestion of the presence of Equidae more advanced than *Merychippus*.

The *Dromomeryx* of the Barstow seems somewhat more advanced and less common than that of the Mascall and Virgin Valley. *Merycodus*, which is abundantly represented in the Barstow, is less common and less advanced in the Virgin Valley, and is unknown as yet in the Mascall.   The relatively primitive *Blastomeryx* is well known in the Virgin Valley, but not found in the Barstow.   *Blastomeryx* has not been reported from the Mascall up to this time.

Rhinoceroses are unknown in the Barstow, but this peculiarity of the fauna may be due to local conditions rather than to stage of development of the fauna.

Comparison of the Barstow fauna with that of the Rattlesnake and Thousand Creek is necessarily limited to a few groups, owing to the small representation of comparable types in the later faunas. The horses of the Rattlesnake and Thousand Creek comprise only advanced types included in the genera *Pliohippus* and *Neohip-*

parion, in contrast to the abundant *Merychippus* fauna of the Barstow. The camels of the Thousand Creek and Rattlesnake are in general larger forms than those of the Barstow. The advanced types of antelopes of the Thousand Creek fauna, represented by *Ilingoceros* and *Sphenophalos*, are much more progressive than *Merycodus* of the Barstow. They are possibly derivatives from the *Merycodus* group, which is not known in beds of the Thousand Creek stage.

The almost total specific distinctness of the Barstow and Ricardo faunas, taken with the wide difference of genera in groups with somewhat similar relations to their environment, makes it impossible to conceive of the two faunas as having existed contemporaneously in regions of quite similar topography only a few miles apart during the time required to deposit the many hundreds of feet of strata in which they occur. Comparison of the Barstow and Ricardo faunas shows that in nearly every comparable group in which there is a noticeable difference the Ricardo forms are more advanced. In the Canidae the typical Barstow *Tephrocyon* disappears in the Ricardo. The aelurodons of the Barstow are, where comparable, less specialized than those of the Ricardo. The protohippine *Merychippus* forms, with a possible rare *Protohippus* or *Pliohippus*, of the Barstow give place to specialized *Hipparion* and *Pliohippus*, with no forms as primitive as *Merychippus*. The camels of the Ricardo include larger forms than those of Barstow. *Dromomeryx* of the Barstow is not known from the type section of the Ricardo, and the Ricardo *Merycodus* appears somewhat more specialized than that of the Barstow.

The difference between the Barstow and Ricardo faunas can scarcely represent a time interval amounting to less than one-third of a geological period as faunal changes are ordinarily interpreted.

The exact relation of the Barstow fauna to that of the Cedar Mountain beds[21] is not entirely clear. The Cedar Mountain carnivores include a *Tephrocyon* apparently identical with *T. kelloggi* of the Virgin Valley, while the *T. temerarius* type of the Barstow fauna is absent. One large Aelurodon-like form of the Cedar Mountain does not seem to be identical with any of the Barstow species. The Hypohippus-like forms of the Cedar Mountain beds

[21] Merriam, J. C., Tertiary vertebrate fauna from the Cedar Mountain Region of Western Nevada, Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 161–198, 1916.

are near the stage of advance in size seen in the species known from the Barstow. Protohippine horses are unfortunately very imperfectly known from the Cedar Mountain beds. One form is near the stage of the Barstow *Merychippus*; another seems relatively advanced, and may be more progressive than any but the most advanced type known from the Barstow. It is possible that more than one faunal horizon is represented in the Cedar Mountain region, and that the two protohippine horses came from different zones.

Merycodus is represented in the Cedar Mountain region most commonly by a type corresponding to *M. furcatus*, though *M. necatus* of the Barstow fauna is also present.

Rhinoceroses are represented in the Cedar Mountain beds, but are not thus far known from the Barstow.

On the whole the faunal assemblage of the Barstow balances near the stage of evolution of the Cedar Mountain beds. The dissimilarity may be due to the presence in the Cedar Mountain region of some horizons older and some younger than those from which the Barstow fauna has been obtained. A portion of the difference may be due to geographic variation. As the horizontal separation is not large and the environments were presumably not greatly different, the geographic factor may not be sufficient to account for the dissimilarity.

In general the Barstow and Cedar Mountain faunas are as near to each other as either is to any other known faunal assemblage in the Great Basin Tertiary series.

Relation to Tertiary Faunas of America Outside the Great Basin Region

The nearest relationships of the Barstow fauna outside the Great Basin are with the Santa Fé beds of New Mexico. Several types which are among the most important forms of the Santa Fé beds are similar to species in the Barstow fauna. These include *Aelurodon wheelerianus*, *Merychippus calamarius*, *Procamelus* near *gracilis*, and *Merycodus necatus*.

As a considerable distance separates the Barstow geographically from the Sante Fé some difference in fauna is to be expected. It is also possible that the Santa Fé beds represent more than one horizon, or may include beds ranging into stages older or younger than the Barstow.

Several peculiarities of the Barstow fauna in comparison with other assemblages of nearly the same age inside and outside the Great Basin are not readily explained. With a considerable collection from the Barstow region, as yet no remains representing rhinoceroses have been seen, while they are known from the nearly allied Cedar Mountain and Santa Fé faunas. As this group was present in America until Pliocene time its absence from the Barstow region may be due to some peculiarity of the environment. It should be noted that rhinoceroses are also unknown in the Ricardo fauna.

Another peculiarity is the absence from the Barstow of *Merycodus furcatus* well represented in the Santa Fé beds. In the Cedar Mountain region both types of *Merycodus* are present, as are also rhinoceroses. The absence of these forms from the Barstow was possibly a peculiarity of this geographic area in Upper Miocene time.

Considering its relation to the recognized Middle Miocene of the Mascall and Virgin Valley, to the Pliocene of the Rattlesnake and Thousand Creek, and to the Upper Miocene of the Santa Fé, the position of the Barstow fauna evidently falls within the Upper Miocene. The position of the Barstow stage with reference to other Miocene faunas of the Great Basin and adjacent regions is approximately as follows:

Period	Great Basin Province	Great Plains and Rocky Mt. Province	Asia	Europe
Upper Pliocene		Blanco		Lignites of Casino
Lower Pliocene	Thousand Creek Rattlesnake Ricardo	Snake Creek	Hipparion fauna of China and Siwaliks in part	Hipparion fauna of Pikermi
Upper Miocene	Barstow Cedar Mountain	Santa Fé		La Grive-Saint Alban
Middle Miocene	Mascall and Virgin Valley	Pawnee Creek		Sansan Sables de l'Orleanais

The Snake Creek fauna[22a] of western Nebraska shows some interesting resemblances to that of the Barstow.   In the Equidae, which apparently furnish the best basis for comparison, the presence of numerous representatives of *Neohipparion, Protohippus,* and *Pliohippus* gives an assemblage much more advanced than that of the Barstow, in which only one form is referred to a genus more advanced than *Merychippus.*   On the other hand the predominance in the Equidae of the Snake Creek fauna of forms of *Merychippus* near those making up the great bulk of the horses of the Barstow area suggests that the times of deposition of some portion of the Snake Creek and of the Barstow were not separated by a wide epoch.

In the Carnivora the Snake Creek possesses an advanced element in certain *Aelurodon* species, which may not be much more progressive than some seen in the Barstow.   With this element at Snake Creek are *Tephrocyon* species, near if not identical with those of the Barstow.

In the artiodactyls, *Dromomeryx* is represented in the two areas; *Merycodus* is represented by closely related forms in Snake Creek and Barstow; the relatively primitive *Blastomeryx* is known at Snake Creek, but not as yet in the Barstow; certain camels at Snake Creek are presumably somewhat more progressive; and the appearance of *Neotragocerus* is probably an advanced character of the Snake Creek assemblage.

A part of the Snake Creek fauna is certainly more advanced than the Barstow, but connecting elements seem to indicate a shorter lapse of time between the Barstow and a portion of the Snake Creek than between the Barstow and Ricardo, as this part of the Snake Creek fauna though more widely removed geographically than the Ricardo is nearer to the Barstow in composition.[22b]

DESCRIPTION OF FAUNA

TESTUDINATA

Testudinate remains are not uncommon in the Barstow beds, but usually consist only of small fragments.   Two specimens repre-

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[22a] Matthew, W. D., and Cook, H. J., A Pliocene Fauna from Western Nebraska, Bull. Amer. Mus. Nat. Hist., vol. 26, pp. 361–414, 1909.

[22b] See recent discussion of this question by W. D. Matthew, Contributions to the Snake Creek fauna, with notes upon the Pleistocene of Western Nebraska, American Museum Expedition of 1916, Bull. Amer. Mus. Nat. Hist., vol. 38, pp. 183–229, pls. 4–10, 1918.

sent the greater part of the carapace and plastron, and a third shows important parts of both carapace and plastron. So far as known all of the material obtained represents land tortoises allied to the Recent genus *Testudo*. This group is represented in the Mohave area at the present time by the desert tortoise *Gopherus agassizii*. Two of the Miocene specimens greatly exceed the living form in size.

TESTUDO MOHAVENSE, n. sp.

Type specimen no. 21575, carapace nearly complete, plastron complete (figs. 4*a*, 4*b*); from the Barstow beds, Barstow syncline, Mohave Desert. Two individuals, nos. 21573 and 21574, much larger than the type specimen, but resembling it in general structure, are tentatively referred to this species.

The characters of this species approximate those of a group of Miocene species referred to the genus *Testudo* though the assemblage of characters does not correspond to that in any of the known forms. In some respects, as in the nature of the epiplastral lip, it resembles the West American Oligocene genus *Stylemys*, but shows clearly a more advanced stage, which is comparable to that of *Testudo*.

The carapace of the type specimen is 232 mm. long with a width of 196 mm. The plastron of the type is 222 mm. long. The more nearly complete of the two large specimens referred to this species is 317 mm. wide and the plastron is approximately 375 mm. long. The carapace of the type (fig. 4*a*) is truncated or concave anteriorly. It is seen to be moderately arched in the type specimen, but distortion of the shell has made exact estimation of the form difficult. In the larger specimens the vault of the carapace is strongly arched. The plastron (fig. 4*b*) is strongly notched posteriorly. The epiplastral lip is strongly developed superiorly, but is not clearly set off from the contour of the posterior portion of the anterior lobe of the plastron. The separation of the epiplastral lip is not more distinct than in *Stylemys* and not less marked than in certain Miocene species of *Testudo*, as in *Testudo pansa*. The anterior lobe of the plastron projects slightly beyond the anterior end of the carapace. The bridge between the plastron and carapace extends from the anterior portion of the second costal to the anterior end of the sixth costal. The form and arrangement of the neural and costal plates are in general as in the *Testudo* group.
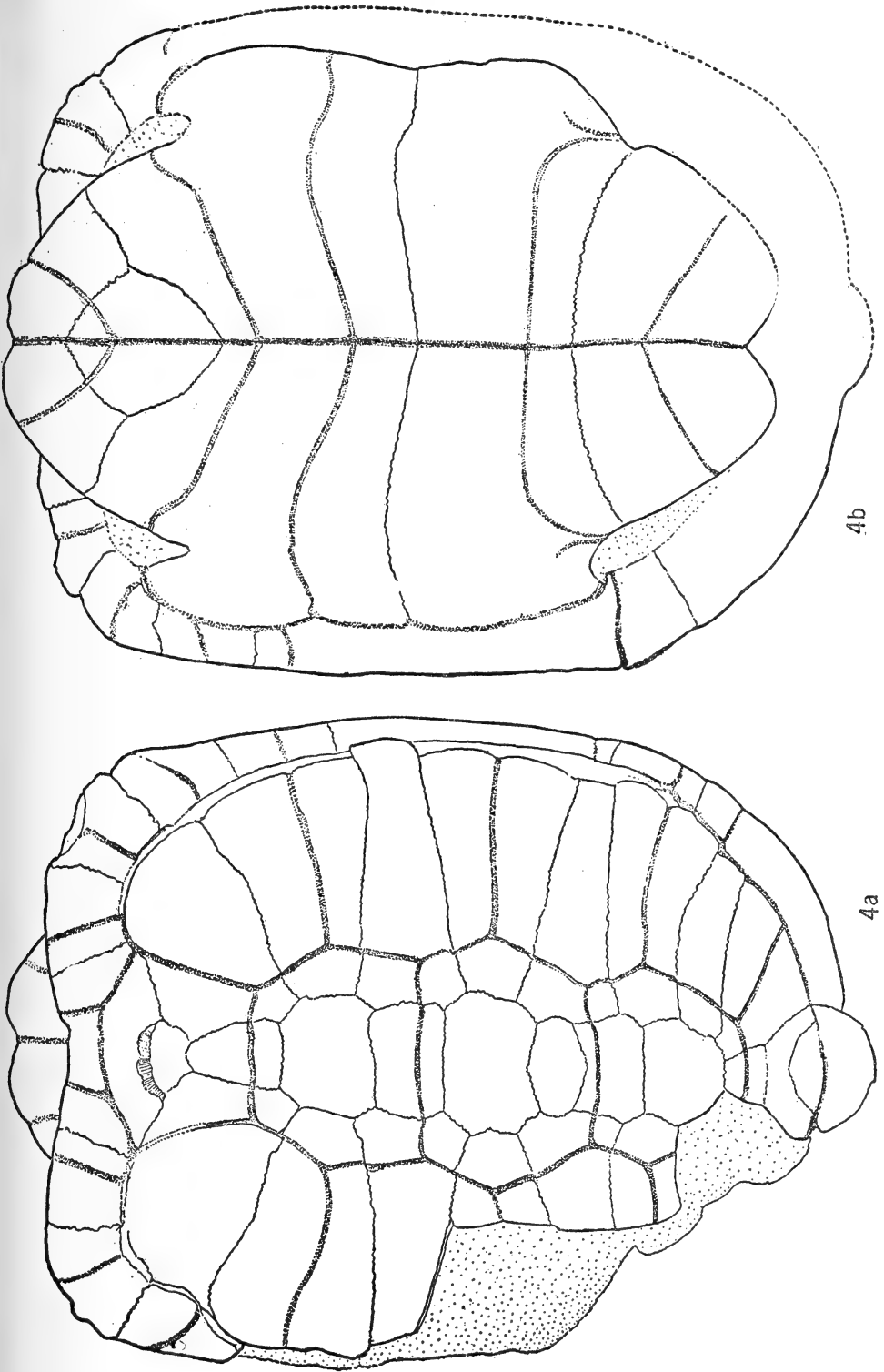
FIGS. 4a AND 4b. *Testudo mohavense*, n. sp. Type specimen, no. 21575, carapace and plastron, × ½. Fig. 4a, carapace from above; fig. 4b, plastron from below. Barstow Miocene, Mohave Desert, California.

Neurals two and four are octagonal, three is tetragonal, five is hexagonal. Neurals three and five are both relatively small. Neurals six and seven are both hexagonal and of nearly the same size, number seven being slightly longer anteroposteriorly. Neural eight is relatively very small and tetragonal. The anterior suprapygial is bifurcated, the posterior wings enclosing the cuneiform second suprapygial, and coming into contact with the lateral borders of the pygial.

The costals from the second to the seventh show much variation between the width of the lateral and median ends. The variation in width between the ends represents the stage of specialization seen in *Testudo* and is more advanced than in the Oligocene *Stylemys*.

Peculiarities in the form of the median series of plates appear in the small, anteroposteriorly-short, hexagonal neural five; in the relatively large size of numbers six and seven; in the small, narrow, tetragonal number eight; and in the contact of the bifid anterior suprapygial with the pygial. The modification in relative size of the fifth and sixth neurals is probably in part responsible for the position of the sulcus between the second and fourth vertebral scutes on the sixth neural instead of on the fifth where it is ordinarily located.

The distal ends of costals three and five are much narrowed and their proximal ends are in articulation with three neurals. Costals two and four are each in contact with one neural. Costal seven is not in contact with neural eight as costal eight wedges in between it and the narrow anterior end of neural eight.

The characters of the neurals and costals may be due in part to individual peculiarities, but are probably to a considerable degree diagnostic of the group. They are suggested in part in other American Tertiary forms, but do not appear in this combination in any other species.

The large specimen, no. 21574 (fig. 5a), differs somewhat from the type specimen in form of the anterior neurals, but the differences seem to be within the limits of individual variation. In no. 21574 neural one is wider than in the type specimen, and tends to be hexagonal. The second neural is also wider in the large specimen. Neural three is relatively large compared with the second, but is tetragonal, while number two is octagonal. The

5b

5a
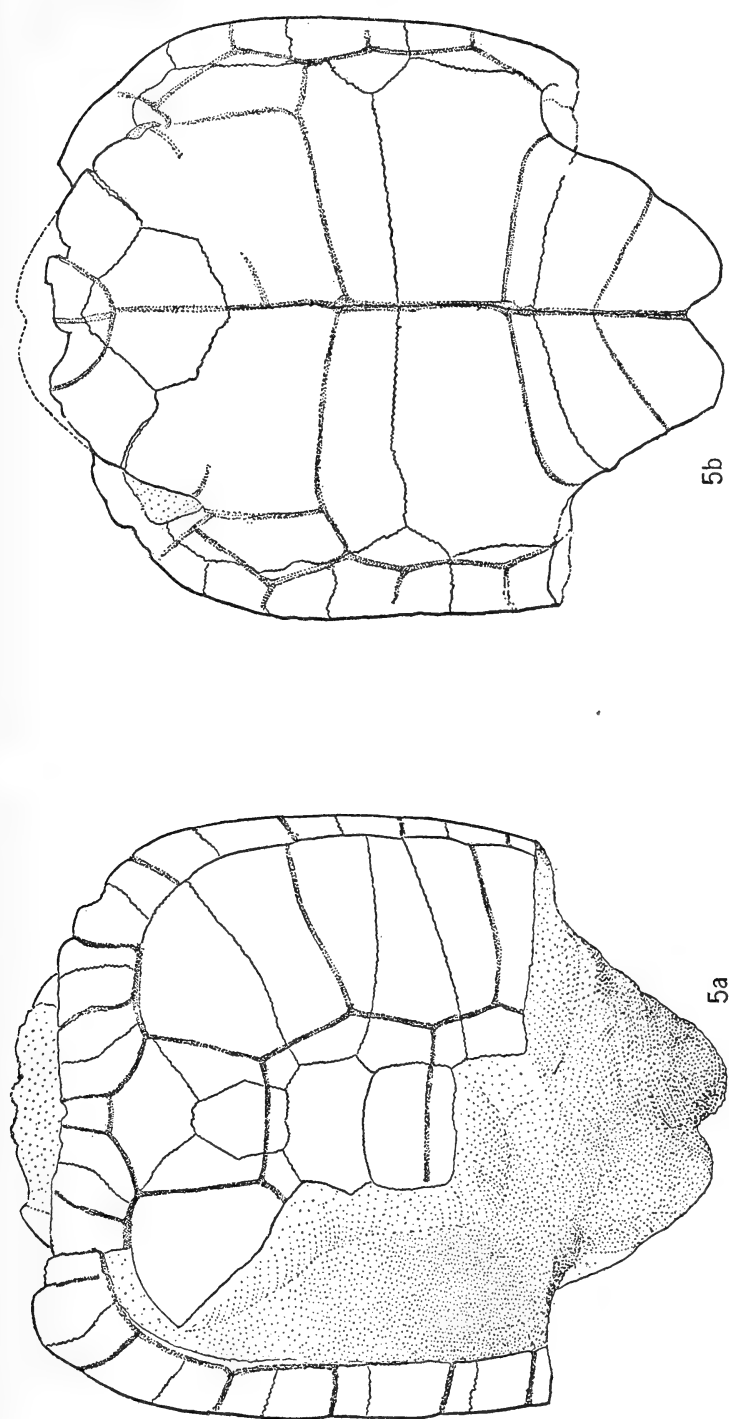
FIGS. 5a AND 5b. *Testudo mohavense?*, n. sp. Carapace and plastron, no. 21574, × ¼. Fig. 5a, carapace from above; fig. 5b, plastron from below. Barstow Miocene, Mohave Desert, California.

third costal in the large specimen is much narrower distally than in the type.

The peripherals on the free anterior and posterior borders of the type specimen have acute margins. On the anterior border they may be slightly flared. The middle of peripheral three is slightly behind the suture between costals one and two.

The pygial plate is considerably wider on the inner than it is on the peripheral margin. Its inner border comes in contact with the distal posterior ends of the bifid first suprapygial.

In the large specimen, no. 21574, the characters of the peripherals are essentially similar to those of the type. In specimen 21574 the peripherals forming the bridge are nearly vertical in position, with a moderate lateral angle. The bridge peripherals of the type may be similar to those of no. 21574, but are less satisfactorily preserved.

The peripherals are united with the costals by a union apparently consisting in each case of a process from the peripheral meeting the end of the costal. The end of the costal evidently passes the outer side of the process of the peripheral and fits into a pit on the peripheral.

The plastron projects considerably beyond the anterior end of the carapace in the type specimen and in the large individual no. 21574. The anterior and posterior ends are both distinctly notched.

The entoplastron is rhomboidal to hexagonal with an angle developed on each posterior border. The hypoplastral-xiphiplastral suture is some distance behind the inguinal notch.

The epiplastral lip is not clearly defined on the anterior border of the plastron, but the lip is strongly developed superiorly. The considerably thickened upper portion of the lip projects backward on the type specimen to a point immediately over or slightly posterior to the anterior end of the entoplastron as it appears on the inferior side of the plastron. On a portion of a large specimen, no. 21573 (fig. 6a), the same relations are observed, but the epiplastral bones overlap the entoplastron superiorly, so that the suture on the upper side is farther from the anterior border. In the type specimen the anterior end of the inferior surface of the epiplastral region is nearly flat. In no. 21573 the anterior end is sharply curved upward (fig. 6b).

The sulci between dermal scutes of the type specimen are sharply impressed but do not have raised borders. The nuchal scute is considerably wider in the type specimen than in no. 21574. In the type, the sulcus between vertebral scutes three and four crosses the sixth instead of the fifth neural as in most species.

On the plastron the humero-pectoral sulcus is well behind the posterior end of the entoplastron. The pectoral scutes have an antero-posterior diameter of 27 mm. on the median side as compared with a width of 49 mm. for the abdominal scutes. This is
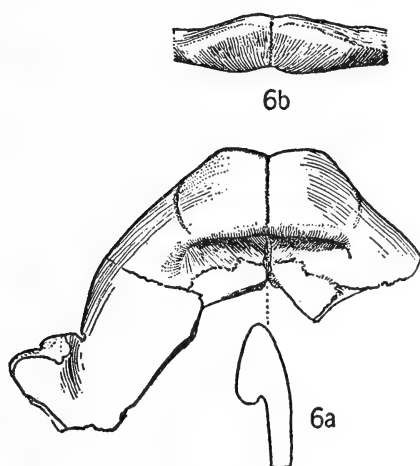
FIGS. 6a AND 6b. *Testudo mohavense?*, n. sp. Anterior portion of plastron, no. 21573, × ¼. Fig. 6a, dorsal view of plastron with section along median line; fig. 6b, anterior view of lip of plastron. Barstow Miocene, Mohave Desert, California.

an unusual width for pectoral scutes in *Testudo*, or even in the more primitive *Stylemys*.

The Barstow Miocene tortoises seem clearly more advanced than the Oligocene *Stylemys* in specialization of the neurals and costals, and to some extent in the development or stage of advance of the epiplastral lip.

The Barstow form seems in the nature of the epiplastral lip, in form of the entoplastron, in width of the pectoral scutes, and in the variations in width of the costals to be less specialized than some of the forms of *Testudo*. The stage of advance is approximately that of Miocene forms like *Testudo pansa* of the Pawnee Creek Middle Miocene or *T. impensa* of the Madison River Upper Miocene.

The Barstow form seems distinct from all of the described species. In view of the fact that *Testudo undata* and *T. klettiana*, described by Cope from the Miocene of New Mexico, are from beds presumably near in age to the Barstow beds the possibility of identity of the species must be considered. *T. klettiana* is described as having a quadrate pygial entirely unlike that of the Barstow species, while *T. undata* is a very large form. With the information available it is not possible to refer the Barstow specimens to either of Cope's species from New Mexico.

MEASUREMENTS

	No. 21575	No. 21574
Carapace, length along median line...	232 mm.	...
Carapace, greatest width............	a196	317
Plastron, greatest length............	222	a375

	No. 21575		No. 21574	
	Length	Width	Length	Width
Nuchal bone......................	33　mm.	72	72	90
Neural bone 1....................	28	18.2	48	39
Neural bone 2....................	24.5	33	40	68
Neural bone 3....................	19.5	32.2	a43	64.5
Neural bone 4....................	23.6	40.2		
Neural bone 5....................	16	25.8		
Neural bone 6....................	17.1	31.5		
Neural bone 7....................	25	31.2		
Neural bone 8....................	19	a14.4		
Anterior suprapygial bone...........	19	35		
Posterior suprapygial bone..........	15.5	25.5		
Nuchal scute.....................	a10.2	29.8	26.5	18.2
Vertebral scute 1..................	42.5	a59	83	82.5
Vertebral scute 2..................	45	62.5	81	a110
Vertebral scute 3..................	50	72		
Vertebral scute 4..................	46.2	57		
Vertebral scute 5..................	45	..		
Pygial bone, length................	24.5			
Pygial bone, width inner...........	36.5			
Pygial bone, width outer...........	a23			

	No. 21575		No. 21574	
	Width proximal	Width distal	Width proximal	Width distal
Costal bone 1......................	....	....	..	..
Costal bone 2................	14.2 mm.	45.8	32	93
Costal bone 3.....................	32.6	16	56	15
Costal bone 4.....................	14.2	45.5	31	79.5
Costal bone 5.....................	30	11.2		
Costal bone 6.....................	16	37		
Costal bone 7.....................	13.2	....		

a, approximate

	Anteroposterior diameter on median line	
	No. 21575	No. 21574
Epiplastrals	19.5 mm.	..
Entoplastron	44	73
Hyoplastrals	53.2	93
Hypoplastrals	44.8	70
Xiphiplastrals	48.7	82
Gular scute	35.6	..
Humeral scute	37.7	74
Pectoral scute	27	46.5
Abdominal scute	48.6	81.5
Femoral scute	35	46.5
Anal scute	28	50

AVES

Very fragmentary remains of birds from the Barstow beds are determined by Dr. L. H. Miller as follows:

Tarsometatarsus of buteonid hawk, as nearly as determinable. Size larger than *Buteo borealis*, locality 2056; tibiotarsus, unmistakably *Buteo*, but size between *B. borealis* and *B. swainsoni*, locality 2061; femur, too fragmentary for determination, may belong with preceding, locality 2061.

CARNIVORA

CANID (CANIS?), sp. small

A fragment of a mandible, no. 19463, represents a small canid form evidently quite distinct from the *Aelurodon* and *Tephrocyon* species to which reference is made below. The mandible (fig. 9, p. 1143) is small and slender, representing a form about as large as a fox. The dentition is not preserved.

TEPHROCYON, near TEMERARIUS (Leidy)

The typical material of this species consisted of a piece of a lower jaw containing the carnassial tooth, and a portion of an upper jaw with two teeth both badly preserved. This material was obtained by Dr. Hayden from the Niobrara sands. The horizon is presumably Upper Miocene. The lower jaw and M_1 figured by Leidy[23] show form and dimensions closely similar to those of a specimen obtained by Peterson[24] from beds at Whistle Creek, Nebraska, possibly belonging to late Miocene or Pliocene deposits.

[23] Leidy, J., Jour. Acad. Nat. Sci. Phila., ser. 2, vol. 7, pl. 1, fig. 12, 1869.
[24] Peterson, O. A., Mem. Carneg. Mus., vol. 4, p. 268, 1910.

A portion of a lower jaw, no. 19402, with P_3 to M_2 inclusive, from the Barstow beds of the Mohave region, California, very closely resembles the type of Leidy's *Canis temerarius* from the Nebraska formation and also resembles the specimen from Whistle Creek, Nebraska, referred to this species by Peterson.[25] M_1 of the Mohave specimen very nearly approaches in form and dimensions the original figured specimen of *Canis temerarius* Leidy, and the Mohave species is almost identical in form and dimensions with the corresponding parts of the specimen described by Peterson.

The specimen from the Barstow beds (fig. 7) represents a species of *Tephrocyon* differing slightly from those thus far known in the Great Basin region. The relationship of this form to the genus
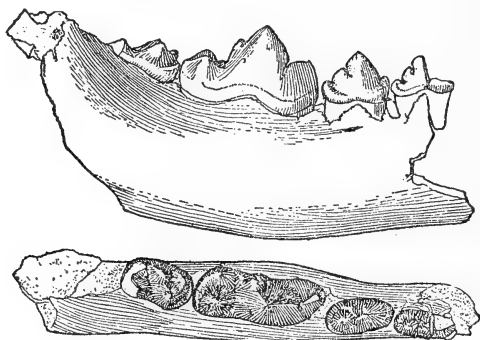
FIG. 7. *Tephrocyon*, near *temerarius* (Leidy). A portion of the mandible with dentition shown in superior and lateral views. No. 19402, natural size. Barstow Miocene, Mohave Desert, California.

Tephrocyon is shown in the large size of the metaconid and of the crushing heel of M_1, and in the presence of a well developed paraconid with a large antero-external shelf on the cingulum of M_2.

The Barstow form is very close to the typical *T. temerarius* but may be separated by subspecific or specific characters when better known. In the Mohave form M_1 seems a little heavier than in Leidy's type.

The Mohave form is distinguished from *Tephrocyon rurestris* and *T. hippophagus* by the smaller, more slender teeth. From *T. kelloggi* it differs in the relatively larger M_1, smaller M_2, and smaller metaconid in M_1. M_1 in the Barstow specimen measures 17 mm. in anteroposterior diameter as compared with 9 mm. in antero-

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[25] See comparison in Notes on the Canid Genus Tephrocyon, J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 366–367, 1913.

posterior diameter in M_2.   In *T. kelloggi* the anteroposterior diameter of M_1 is 15 mm.; of M_2, 10.5 mm.   There is a small hypoconulid on the heel of M_1 in the Barstow specimen, while in the type of *T. kelloggi* this tubercle is not suggested.   The heel of M_2 seems somewhat shorter than in *T. kelloggi*.

P_4 and P_3 both possess a posterior cusp and a posterior basal tubercle. P_4 shows a small anterior basal tubercle.   The anterior side of P_3 is not preserved.

Several specimens of mandibles slightly larger than no. 19402 represent a *Tephrocyon* species from the Barstow beds very near *T. temerarius*.   It is possible that they belong to another species,

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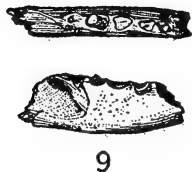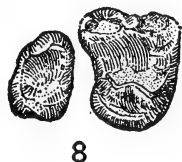
Fig. 8.   *Tephrocyon*, near *rurestris* (Condon). M^1 and M^2, no. 21512, occlusal view, natural size.   Barstow Miocene, Mohave Desert, California.

Fig. 9.   Canid, sp. small.   Fragment of mandible, no. 19463, lateral and dorsal views, $\times \frac{1}{2}$.   Barstow Miocene, Mohave Desert, California.

but age and sex are presumably competent to account for the differences.

A portion of an upper jaw, no. 21512, with M^1 and M^2 imperfectly preserved (fig. 8) shows a form of molar teeth near that in *T. rurestris*, the type species of *Tephrocyon*.   A portion of an upper jaw, no. 21513, with fragments of the premolars also suggests the characters of *Tephrocyon*.

AELURODON, near WHEELERIANUS Cope

Several mandibles in the collection from the Barstow represent large, heavy-jawed canids of the *Aelurodon* type (figs. 10 and 11).   Unfortunately no one of the several specimens shows the dentition well enough to permit a fully satisfactory comparison

with the described material. In general the characters of these specimens are, however, quite close to those of *A. wheelerianus* described by Cope from the Upper Miocene of the Santa Fé region.

In forms of the types seen in no. 19398 (fig. 10) the mandible is very thick and massive; the heavy teeth are closely spaced, with a
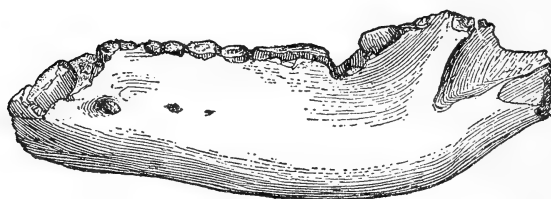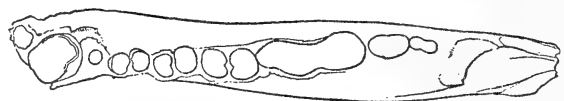
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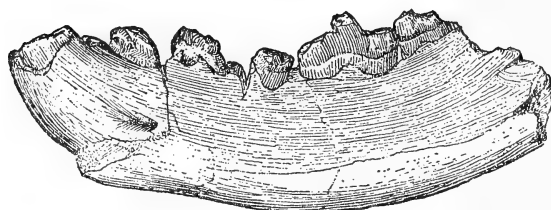
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FIG. 10. *Aelurodon*, near *wheelerianus* Cope. Mandible, no. 19398, lateral and superior views, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 11. *Aelurodon*, near *wheelerianus* Cope. Mandible, no. 21231, lateral and superior views, × ½. Barstow Miocene, Mohave Desert, California.

tendency to be set transverse to the long axis of the jaw, there is almost no diastema, the roots of the premolars are very thick, and M_2 is relatively small. Especially noticeable is the very massive character of the ramus, which has nearly twice the bulk of that in a timber wolf with a cheek-tooth series of approximately the same anteroposterior diameter.

MEASUREMENTS

	A. wheeler-ianus type	No. 19455 Barstow	Canis pam-basileus
Length, anterior side P_1 to posterior side M_3.........	95 mm.	88.5	92.7
M_1, anteroposterior diameter.......................	28	28.4	28
M_2, anteroposterior diameter.......................	12	10.3	12.2
Depth of jaw below M_2...........................	35	a35.5	30
Greatest thickness of jaw below M_2................	17	18	11.7

   a, approximate.

The larger part of a mandible with imperfect dentition, no. 21231 (fig. 11), shows a form in which the mandible is thick inferiorly, but thinner above than in the common *Aelurodon* of the Barstow fauna. M_2 is considerably larger than in the common form. This species resembles the typical *Aelurodon wheelerianus* in many ways, and the distinctive characters of the specimen may be due merely to individual variation, or they may indicate a species distinct from that represented by no. 19398.

MEASUREMENTS OF No. 21231

Length, anterior side of inferior canine to posterior side M_1..........	98	mm.
Length of lower premolar series.................................	a52	
Inferior canine, anteroposterior diameter at base..................	a24.7	
P_3, anteroposterior diameter...................................	a13	
M_1, anteroposterior diameter...................................	25.8	
M_1, transverse diameter.......................................	11.9	
M_2, anteroposterior diameter...................................	a13	
M_2, transverse diameter.......................................	8.3	

   a, approximate.

AELURODON, DINOCYON, or AMPHICYON, sp.

A portion of a very large, much-weathered lower jaw, no. 21224, with the base of the canine represents a form much larger than *Aelurodon wheelerianus*. It may represent an *Aelurodon*, an *Amphicyon*, or a *Dinocyon* species. The space for incisors is small. The alveolus for P_1 is very small.

CANID SKELETAL ELEMENTS, indet.

A number of scattered skeletal elements representing forms of the canid type have been obtained in the Barstow. Noteworthy among the canid skeletal remains are a number of phalangeal elements which are considerably heavier than those of the typical wolves. A second and fifth metapodial of the anterior extremities (figs. 12a, 12b) represent this type. The short-headed, heavy-jawed tephrocyons and aelurodons of the Barstow fauna were
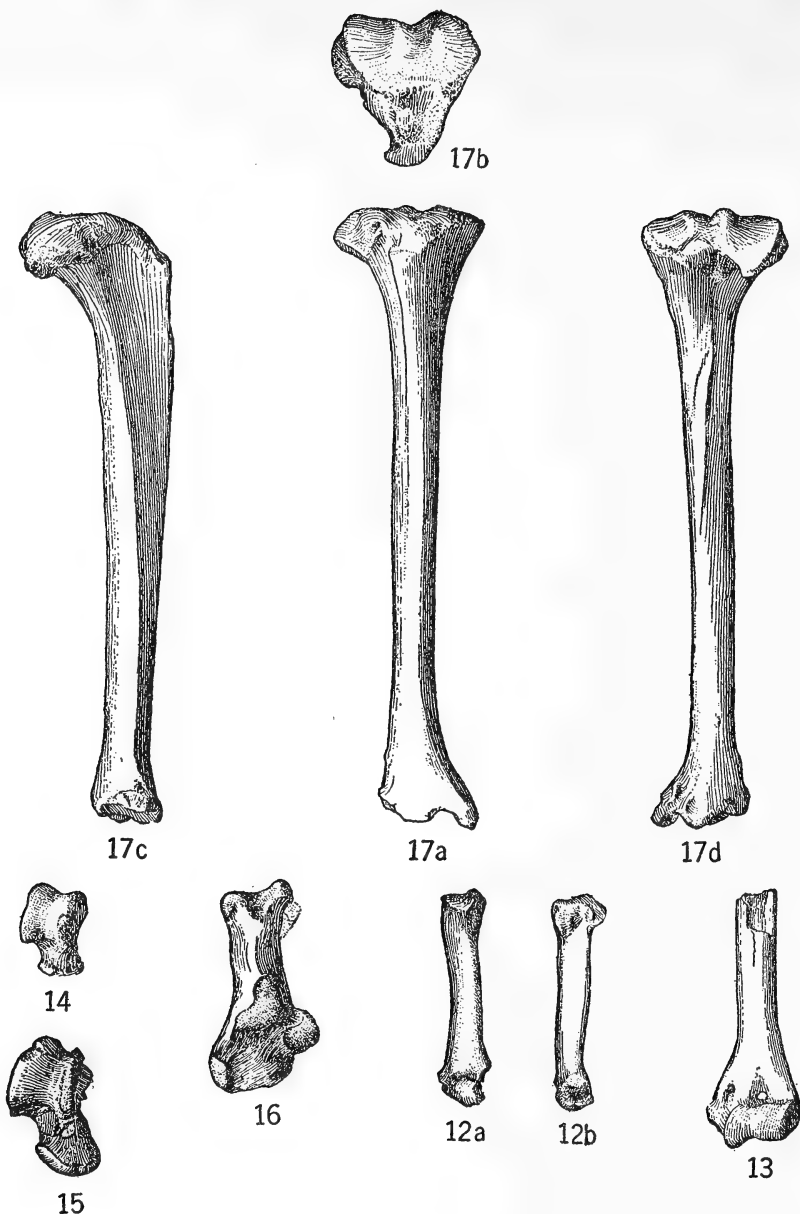
FIGS. 12a AND 12b. Canid, indet. Second metacarpal?, no. 19469, $\times \frac{1}{2}$. Fig. 12a anterior view; fig. 12b, median view. Barstow Miocene, Mohave Desert, California.

FIG. 13. Canid, indet. Humerus, no. 19468, anterior view, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 14. Canid, indet. Astragalus, no. 19469, tibial view, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 15. Canid, indet. Astragalus, no. 23119, tibial view, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 16. Canid, indet. Calcaneum, no. 23120, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIGS. 17a TO 17d. Canid, indet. Tibia, no. 19470, $\times \frac{1}{2}$. Fig. 17a, anterior view; fig. 17b, view of proximal end; fig. 17c, lateral view; fig. 17d, posterior view. Barstow Miocene, Mohave Desert, California.

presumably heavy-limbed, and it may be that the specimens before us represent one of these forms.

A humerus (no. 19468, fig. 13) from the Barstow shows in general the characters of this element in the canids, but is distinguished by the presence of an entepicondylar foramen.

A small, long-necked astragalus (no. 19469, fig. 14) resembles an astragalus from the Middle Miocene of Virgin Valley, and is possible with the Virgin Valley form to be referred to *Tephrocyon*.

A complete tibia and the distal end of a femur of the same animal represent a canid form presumably about as large as a coyote. The distal portion of the femur is much heavier than in the coyote, but the shaft is more slender than in a greyhound specimen before the writer. The tubercle situated on the outer border of the popliteal surface is relatively about as prominent as in the coyote, but is relatively larger than in the greyhound.

The tibia (fig. 17a) has approximately the length of that in the coyote, but is much heavier, the increased bulk being particularly noticeable in the proximal half. The proximal end (fig. 17b) is much wider across the condyle than in the coyote; the heavy cnemial crest does not end distinctly above the middle of the shaft, but extends downward as a well marked ridge into the lower third of the shaft where it gradually fades. This character of the crest gives to the lateral view (fig. 17c) of the tibia quite a different outline from a similar view of the tibia of the coyote or of the greyhound. In the postero-superior region of the tibia the interosseous ridge is sharply marked, but the internal border is gently rounded instead of sharply angular as in the coyote and greyhound. The popliteal line arises on the inner or medial side of the popliteal notch instead of on the outer side as in the greyhound and coyote. The posterior side of the shaft is relatively narrow and less distinctly flattened than the coyote and greyhound.

MACHAERODONT, sp. A

The distal ends of several humeri belong to felid forms about as large as the Recent puma, and may represent one of the machaerodont forms described below. It is not possible to determine with certainty the genus to which they belong. On one specimen, no. 19465, there is a deep fossa on the anterior side (fig. 18) laterad of the entepicondylar foramen. The depression is evidently formed
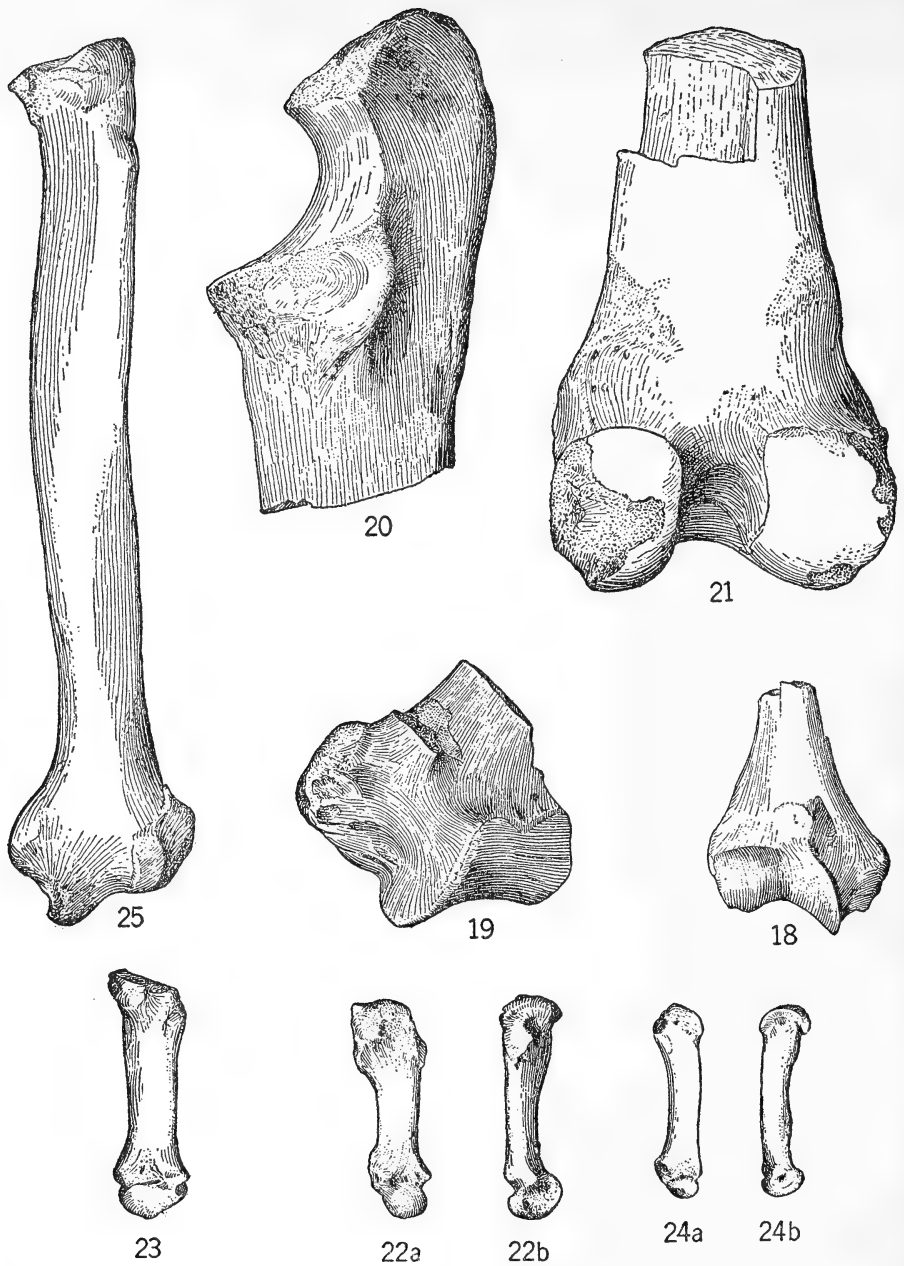
Figs. 18 to 25 represent felid forms from Barstow Miocene, Mohave Desert, California, × ½.

Fig. 18, Machaerodont, sp. A, Distal portion of humerus, no. 19465; fig. 19, Machaerodont, sp. B, fragment of distal end of humerus, no. 21223, anterior view; fig. 20, Machaerodont, sp. C, ulna, no. 21352; fig. 21, Machaerodont, sp. C, femur, no. 21352, posterior view; figs. 22a and 22b, Machaerodont, indet., metacarpal 5, no. 19466, fig. 22a, anterior view, fig. 22b, median view; fig. 23, Machaerodont?, indet., metacarpal 1, no. 21515, anterior view; figs. 24a and 24b, *Aelurodon?*, or Felid?, indet., metacarpal 5, no. 19399, fig. 24a, anterior view, fig. 24b, median view; fig. 25, Felid, possibly feline, indet., radius, no. 23121, anterior view.

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to accommodate the coronoid process of the ulna, and suggests frequent extreme pronation of this extremity.

MACHAERODONT, sp. B

A second type of humerus represented by no. 21223 (fig. 19) belongs to a much larger cat, probably a machaerodont.

MACHAERODONT, sp. C

A third type is represented by a portion of a gigantic ulna and femur, no. 21352 (figs. 20 and 21).   This material evidently indicates a machaerodont form at least as large as the Pleistocene *Smilodon* of Rancho La Brea.

MACHAERODONT, indet.

A number of other loose limb elements are evidently to be referred to some of the types distinguished above.   Several felid metapodials represent a machaerodont cat about as large as a puma.   Among them is a metapodial five of the anterior limb, no. 19466 (figs. 22a, 22b), a moderately heavy element.   The type of a foot represented by this phalanx seems heavier than in *Dinictis*, and a little less massive than in *Smilodon*.   No. 21515 (fig. 23) possibly belongs to the same species.   No. 19399 (figs. 24a, 24b) represents a smaller form of heavy metapodial possibly representing *Aelurodon*.

It is evident from the limb material present that at least three types of large cats were present in the Barstow fauna.

FELID?, indet.

The posterior end of a mandible, no. 21571 (figs. 26a and 26b), is from a form approximating the size of the Recent African lion, and would seem to have feline rather than machaerodine characters if it represents the cats.   The angle is separated by a considerable distance from the condyle.   It protrudes well behind the condyle, and is situated almost immediately below the base of the coronoid process.   These characters generally distinguish the feline type from the more specialized machaerodine forms, in which the angle is nearer the condyle, does not project markedly behind the condyle, and is situated beneath the outer end of the condyle some distance laterad of the base of the coronoid process.

PSEUDAELURUS, sp.

A portion of a lower jaw without teeth (no. 21516, fig. 27) from the Barstow beds represents a cat of the *Pseudaelurus* type not differing greatly from *P. intrepidus* of the Upper Miocene Nebraska beds. The Barstow specimen approaches the type specimen of *P. intrepidus* in dimensions and in proportions of teeth and jaw,
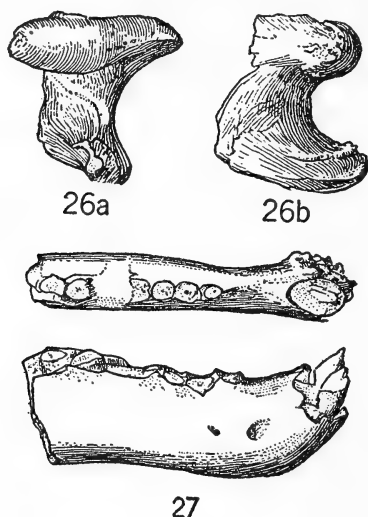

26a   26b

27

Fɪɢ. 26*a* and 26*b*.   Felid?, indet.   Posterior end of mandible, no. 21571, × ½.   Fig. 26*a*, posterior view; fig. 26*b*, inner view.   Barstow Miocene, Mohave Desert, California.

Fɪɢ. 27.   *Pseudaelurus*, sp.   Mandible, lateral and dorsal views, no. 21516, × ½.   Barstow Miocene, Mohave Desert, California.

but seems slightly heavier. The California form possibly represents a distinct species, but this is not clearly demonstrated by the available material.

Mᴇᴀsᴜʀᴇᴍᴇɴᴛs

	No. 21516	P. intrepidus type
Height of mandible below anterior end of P$_4$	25.8 mm.	23.3
Greatest thickness of mandible below anterior end of P$_4$	12.5	12.3
Approximate length, posterior border P$_4$ to posterior border inferior canine	39.5	40.3

Of the Old World forms *Pseudaelurus quadridentatus* from the Miocene of Sansan is apparently as near to the Barstow form as any of the described species. The forms from Pikermi recently referred to a new genus, *Paramacherodus*, by Pilgrim are distinguished by the more prominent anteroinferior angle of the man-

dible.   This is also true of the *Paramacherodus* specimens from the Middle Siwaliks of India.   *Sivaelurus* of the lower Siwaliks shows less prominence of the anteroinferior angle, as in the California *Pseudaelurus*, but one might suspect that the third inferior pre-molar is relatively smaller and that the form of the jaw is not identical in the two types.   Lydekker's specimen of *Aelurogale sivalensis* described from the Siwaliks of the Punjab[26] shows rather more resemblance to the Barstow form, but Lydekker's specimen is referred by Pilgrim to the genus *Paramachaerodus*.

RODENTIA

LEPUS?, sp.

A few fragmentary remains, no. 21232, from locality 2056, repre-sent a rabbit-like form from the Barstow beds.   An astragalus from locality 1396 is similar to that of *Lepus*.

PROBOSCIDEA

TETRABELODON?, sp.

Numerous fragmentary remains of proboscideans have been found in the Barstow fauna, but in general they indicate nothing more than the presence of a large Tetrabelodon-like form with somewhat advanced cheek-teeth on which the enamel may have a thickness of 8 mm. or more.   On one specimen there is a trace of enamel on the tusk.

EQUIDAE

Remains of forms representing the Equidae are the most abun-dant fossils in the exposures of the Barstow syncline.   Especially at one horizon, known as the Merychippus bed, in the upper portion of the section referred to by Baker[27] as the Fossiliferous Tuff mem-ber, scattered bone fragments and teeth are common.   At least five species are known, two anchitheriine and three protohippine forms.   The brachyodont forms comprise a large species of *Hypo-hippus*, possibly of the subgenus *Drymohippus*,[28] recently described from the Tertiary beds near Mina in southwestern Nevada, and a smaller form near *Parahippus*.[29]   The protohippine forms include

[26] Lydekker, R., Mem. Geol. Surv. India, ser. 10, vol. 2, pl. 44, figs. 7 and 7a, 1884.
[27] Baker, C. L., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 346, 1911.
[28] Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 420, 1913.
[29] *Ibid.*, p. 427, 1913.

advanced species of *Merychippus* and a form presumably near *Protohippus*.

The brachyodont horses are very rare. A single jaw fragment of *Hypohippus* is known, and the number of skeletal elements referred to this group is relatively very small. Of the Parahippus-like form only two specimens are known, one representing the upper, the other the lower, dentition. The collections of horse specimens from the Barstow syncline consist mainly of *Merychippus*, with a small percentage of more advanced forms evidently close to *Protohippus*.

HYPOHIPPUS, near AFFINIS (Leidy)

This genus is represented in the collections from the Barstow syncline by a fragment of a lower jaw with M_1 and M_2 from locality 2060, a fragment of an upper molar from locality 2058, and a few limb bones from localities 1398 and 2056.
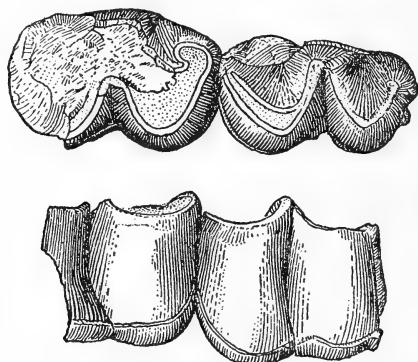
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FIG. 28. *Hypohippus*, near *affinis* Leidy. M_1 and M_2, no. 21215, natural size. Barstow Miocene, Mohave Desert, California.

The molars (fig. 28) in the lower jaw fragment, no. 21215, represent a very large species comparable in size to *Hypohippus affinis* of the Upper Miocene in the Great Plains region, or approximately comparable with *H. nevadensis* of the Stewart Valley beds in southwestern Nevada. Unfortunately the lower teeth of *H. nevadensis* of the Stewart Valley beds in southwestern Nevada are not certainly known. The dimensions correspond very closely with teeth from the Upper Miocene of Big Spring Cañon, South Dakota, described by Matthew and Gidley.[30] This species seems very near

[30] Matthew, W. D., and Gidley, J. W., Bull. Am. Mus. Nat. Hist., vol. 22, p. 135, fig. 1, 1906.

H. affinis, but is possibly to be referred to *H. nevadensis* from an adjacent area. Were it not that the milk dentition of both *H. affinis* and *H. nevadensis* are known, it would be difficult to find means of separating the Nevada species from *H. affinis*.

A fragmentary upper molar, no. 21214, shows no characters more than that it is a large species of *Hypohippus*.

MEASUREMENTS OF No. 21215

M_1, approximate anteroposterior diameter	28.2 mm.
M_1, greatest transverse diameter	20
M_2, anteroposterior diameter	29.5
M_2, greatest transverse diameter	17.4
M_2, height of crown at middle of occlusal face	19.5

A number of phalanges of digit three, the distal end of a metapodial, several astragali, and a calcaneum from the Barstow collections apparently represent *Hypohippus*.
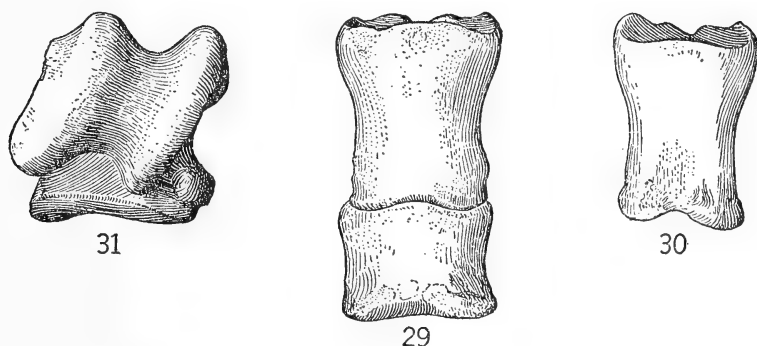
FIG. 29. *Hypohippus*, near *affinis* (Leidy). Phalanges 1 and 2, no. 21216, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 30. *Hypohippus*, near *affinis* (Leidy). Phalanx 1, no. 21211, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 31. *Hypohippus*, near *affinis* (Leidy). Astragalus, no. 21467, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

The phalanges (figs. 29 and 30) are larger and relatively much wider or flatter than those of members of the *Merychippus* group. In the proximal phalanges of the third digit, the median groove for the distal keel of the metapodial is limited to the posterior region of the articular face.

A portion of a large, low, wide hoof, no. 21468, evidently represents *Hypohippus*.

A number of large astragali (fig. 31) show the wide and relatively

shallow trochlea distinguishing this genus from *Merychippus*, in which the groove is narrower, deeper, and relatively sharper. A very large calcaneum evidently represents *Hypohippus*.

Judging from the size of the limb elements *Hypohippus* furnished the largest members of the Equidae of the Barstow fauna.

<div align="center">MEASUREMENTS</div>

<pre>
Phalanx 1, digit III, no. 21216
      Greatest length.. 49.3 mm.
      Greatest proximal width.................................. 40.7
Phalanx 2, digit III, no. 21466
      Greatest length.. 30
      Greatest proximal width.................................. 43
Astragalus, no. 21467
      Greatest length.. 54.5
      Least width across trochlea.............................. 41
Calcaneum, no. 21465
      Greatest length.. 106
</pre>

The proximal end of a very large metacarpal III (no. 21406, locality 2056, fig. 32) differs from the type of the Merychippus-like
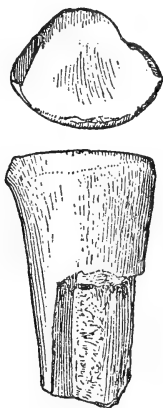
FIG. 32. *Hypohippus?*. Proximal end of metacarpal 3, no. 21406, × ½. Barstow Miocene, Mohave Desert, California.

forms of the Barstow fauna and may represent *Hypohippus*. In addition to difference in size the large form is distinguished by greater width of the proximal face and by an anteroposteriorly longer unciform facet. One objection to referring it to *Hypohippus* is the fact that it is associated with the distal end of a metapodial quite unlike the better known forms of *Hypohippus* in possessing a complete distal keel.

Several relatively large proximal ends of metatarsal IV differ from the common specimens evidently representing *Merychippus* in the Barstow fauna, and are presumably to be referred to *Hypohippus*. These metapodials are distinguished from metatarsal IV specimens referred to *Merychippus* in much larger size, relatively wider cuboid facet, position of the median facet for contact with the metatarsal III more nearly transverse to the plane of lateral compression of the bone, and in apparent absence of a posterior facet for articulation with metatarsal III.

PARAHIPPUS? MOURNINGI Merriam

Parahippus mourningi Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 427, 1913.

A portion of a lower jaw with dentition (fig. 33) obtained by Mr. Baker in 1911 has been described by the writer as *Parahippus*
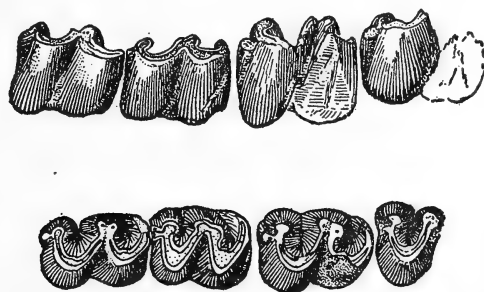
FIG. 33. *Parahippus? mourningi* Merriam. P_3 to M_2, no. 19764, natural size. Barstow Miocene, Mohave Desert, California.

mourningi, a horse with characters near *Parahippus* and *Hypohippus*, but with size and stage of evolution near *Archaeohippus*. The specimen differed, however, from the only lower jaw material referred to *Archaeohippus* in several characters, and especially in the absence of the strong internal cingulum shown on teeth referred to *Archaeohippus* by Gidley. In January, 1913, a second specimen, a maxillary (fig. 34) with Dm^3, Dm^4, and M^1, representing a very small brachyodont horse, was obtained in the Mohave region by Buwalda and Mourning. An approximation of the dimensions of the cheek-tooth series, as well as a comparison of individual teeth, shows that the upper and lower jaw specimens represent animals of very nearly the same size. The similarity of dimen-

sions, considered with similarity of relationship to other forms and similarity of occurrence, leaves little room for doubt that the two jaws represent the same species.

In the specimen representing the upper jaw, the well-preserved, unworn, inner portion of M^1 shows the metaloph fully united with the ectoloph. The protoconule is distinctly separate from the protocone; it is considerably elongated and flattened and its inner end overlaps the protocone. The hypostyle is larger than in *Hypohippus* and *Archaeohippus*, and there is a more distinct cuplike depression behind it. There is no suggestion of a crochet, though several plate-like projections arise from the anterior side of the outer end of the metaloph. The cingulum is well developed on the posterior side, and less distinctly on the anterior side between

34   35
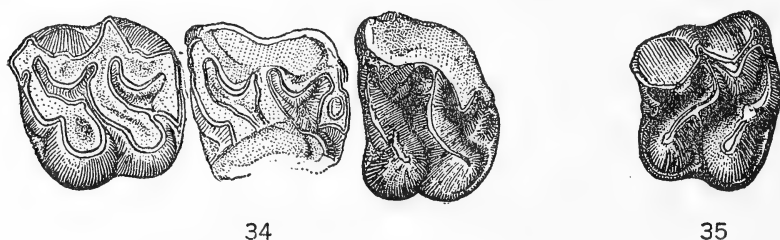
FIG. 34. *Parahippus? mourningi* Merriam. Dm³, Dm⁴, and M¹, no. 19840, × 1½. Barstow Miocene, Mohave Desert, California.

FIG. 35. *Archaeohippus ultimus* (Cope). Upper molar, no. 1689, × 1½. Mascall Middle Miocene, John Day Region, Oregon.

the protocone and protoconule. There is no shelf of the cingulum on the inner or lingual side of the tooth. The cusps or ridges of the crown are somewhat higher than in *Archaeohippus* or in *Hypohippus*. The surface shows a degree of rugosity more pronounced than seems characteristic of *Hypohippus* or of *Archaeohippus*. No trace of cement is evident upon the crown.

The crowns of the milk molars of the Barstow specimen were apparently somewhat shorter and slightly rougher than those of the permanent molars. As in the permanent dentition, the milk molars show the metaloph connected with the ectoloph, there is no internal or lingual shelf of the cingulum, and the hypostyle is large. A P^2 from the Mascall Miocene, considered by Gidley to represent *Archaeohippus*, differs from the milk molars of the Barstow specimen in showing much greater development of the longitudinal ribs

on the outer side of the paracone and metacone.   There is a very faint longitudinal rib on the outer face of the paracone in Dm³ of the Barstow specimen.   A longitudinal rib is barely perceptible on the outer side of the metacone of this tooth.

<div align="center">MEASUREMENTS</div>

	No. 19840	Archaeohippus ultimus Type specimen	Archaeohippus ultimus No. 1689
Dm³, greatest anteroposterior diameter......	13 mm.	P³ 12	....
Dm³, transverse diameter..................	13.8	P³ 16	....
Dm⁴, greatest anteroposterior diameter......	13.7	P⁴ 13	....
Dm⁴, transverse diameter..................	a14.5	P⁴ 17	....
M¹, anteroposterior diameter measured along middle of crown........................	13.7	M¹ 11	....
M¹, approximate transverse diameter measured along anterior border...........	a16	M¹ 15	....
M³, anteroposterior diameter measured along middle of crown........................	....	11	11
M³, transverse diameter along anterior border................................	....	14	14.8

a, approximate.

In the lower jaw specimen, no. 19764 (fig. 33), the cheek-teeth are brachyodont, without evidence of cement covering.   The crowns of the molars and premolars are slightly rugose, and tend to be somewhat higher than in the average *Hypohippus*. P_4 is considerably larger than M_1 in both anteroposterior and transverse diameter.   The metaconid and metastylid show a distinct tendency to separate at the summit, the separation being more marked than in typical *Hypohippus*, and less advanced than in typical *Parahippus*.   The entostylid is well developed.   The cingulum is well shown on the anterior and posterior sides of the crown, but shows no distinct shelf on the outer and inner sides.

The dentition of specimen 19764 differs from the lower teeth referred to *Archaeohippus* by Gidley in the absence of external and internal cingula, and apparently also in the proportions of the premolars.

The form represented by the lower jaw, no. 19764, shows a general resemblance to *Hypohippus*, but differs in its slightly higher and more rugose crowns, more clearly marked incipient separation of metaconid and metastylid columns, and absence of external basal cingulum.

This form differs from typical *Parahippus* in the very weak sepa-

ration of the metaconid and metastylid columns, and in the absence of cement from the crowns. The separation of metaconid and metastylid in no. 19764 shows but little advance beyond the stage seen in the dentition of a *Hypohippus* specimen from Virgin Valley. In none of the cheek-teeth of no. 19764 are metaconid and metastylid pillars separated on the inner side by more than a faint groove at the summit.

MEASUREMENTS

	No. 19764	Archaeohippus ultimus No. 1700
Length, anterior side of P_3 to posterior side of M_2	60 mm.	....
P_2, approximate anteroposterior diameter	16	11.5
P_3, approximate anteroposterior diameter	15.8	12
P_3, transverse diameter across hypoconid	10.5	9.8
P_4, anteroposterior diameter	15	....
P_4, transverse diameter across hypoconid	10.5	....
M_1, greatest anteroposterior diameter	13.6	....
M_1, transverse diameter across protoconid	9	....
M_2, greatest anteroposterior diameter	13.6	....
M_2, transverse diameter across protoconid	8.5	....

The upper and lower jaw specimens (nos. 19840 and 19764) from the Barstow resemble each other in a number of important particulars. Their similarity in structure and their occurrence in the same region gave a reasonable assurance that they represent the same type. The two specimens show similarity in the following characters: (1) height of tooth crowns; (2) rugosity of enamel; (3) absence of cingulum on the protocone side; (4) stage of development, as seen in separation of metaconid and metastylid, in increase of size and compression of the protoconule, in complication of the metaloph, and in increase of size in hypostyle. The stage of evolution in the two specimens shows about equal advance beyond the dentition of the *Hypohippus*.

The Barstow type represented by specimens nos. 19840 and 19764 is evidently related to *Parahippus* in most characters, though distant from the typical form. The absence of a crochet in the upper teeth, and the very slight separation of metaconid and metastylid columns in the lower teeth, indicate a relatively undeveloped stage. Whether this form is too primitive to be included in *Parahippus* will be determined more clearly when better material is available for study.

Some significance may attach to the fact that this form, having a certain resemblance to *Parahippus*, but being relatively primitive, occurs in strata which were presumably deposited in a later period than the time of maximum development of the genus *Parahippus*. On the other hand, the Barstow form, being somewhat more advanced than *Archaeohippus* in most respects, and occurring in strata presumably younger, might be considered a product of modification from *Archaeohippus*. It is interesting to note that in the development of the crochet, in which one would expect advance, the Mohave form is more primitive than the Middle Miocene *Archaeohippus*.

The form represented by *Parahippus? mourningi* might be assigned tentatively to a place with *Archaeohippus*, as an advanced stage with protoconule and hypostyle more progressive, cingulum of the protocone side absent and complication of the metaloph not more advanced. It might be referred to *Parahippus*, as a primitive stage with crochet undeveloped, though the metaloph shows secondary folding, and with metaconid and metastylid in beginning separation. Its reference to one of the described genera depends somewhat upon the extent to which the limits of these groups may be expanded by later studies. A reference to *Parahippus* is apparently open to fewer definite objections than a reference to *Archaeohippus*.

MERYCHIPPUS Leidy

The remains of *Merychippus* are much the most common fossils throughout the Barstow wherever it has been examined. In the uppermost or Fossiliferous Tuff member of the Barstow syncline, mammalian remains are relatively much more abundant than in the other portions of the beds and *Merychippus* is the most common form. One zone, in which bones of this form were especially abundant was known in the field as the Merychippus bed. According to Baker, this stratum could be traced for a considerable distance. The presumption is that the Merychippus bed represents a deposit formed with unusual slowness, and possibly at a time when conditions bringing retardation of accumulation made the region an especially favorable habitat for animal life.

The *Merychippus* forms found in the Barstow seem to differ from the species of the Mascall and Virgin Valley, and also from

all of the species in the Ricardo fauna. The Barstow forms are all more progressive than those of the Mascall stage, and with one possible exception they are all less progressive than the species of the Ricardo. Whatever be the ultimate position of these three faunal zones with reference to the palaeontologic or geologic scale in other regions, there seems no doubt that the horses of the Barstow fauna represent a stage intermediate in time between the Mascall Middle Miocene preceding and the Ricardo following.

Upper Cheek-Teeth.—The numerous Merychippus-like specimens from the Barstow fauna resemble *Merychippus calamarius* (Cope) in many respects, but show a wide range of variation in the characters of the upper cheek-teeth. These teeth vary between small forms with discrete protocone and complex enamel folds bordering the fossettes on the one hand; and large long-crowned forms with wide, simple fossettes, and protocone connected with the protoconule. The largest specimens are somewhat larger than the type of *Merychippus calamarius*, the smaller ones are considerably smaller. The difference in structure between the large and small forms may amount to more than specific distinction as ordinarily interpreted. It is comparable in general to the difference between the genera *Merychippus* and *Protohippus*, but the gradations between the forms are such that with the available material the writer finds it difficult to separate distinct groups of more than specific rank.

The largest form is separated as a species distinguished from *Merychippus calamarius* and approaching *Protohippus*. It has been described as *Merychippus* (*Protohippus*) *intermontanus*[31] (figs. 36 to 40). This species is characterized by relatively large size; long tooth crowns; curved, heavily cemented upper cheek-teeth with protocone uniting with protoconule, and with relatively simple enamel walls bordering the fossettes.

A small type has been set off as *Merychippus sumani*.[32] It is distinguished (figs. 41 and 42) by relatively small size and curved, well cemented, upper cheek-teeth with protocone tending to circular cross-section even in advanced stage of wear, and with relatively complicated enamel folds bordering the fossettes.

After separation of *M. sumani* and the large species included in

[31] Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 50–51, 1915.
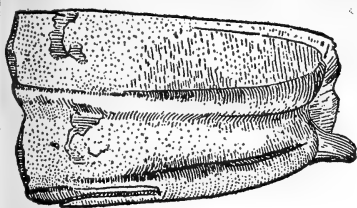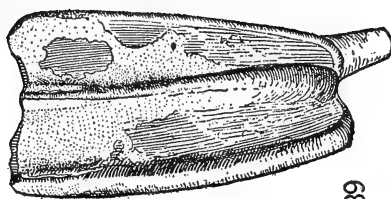[32] *Ibid.*, pp. 49–50, fig. 1, 1915.
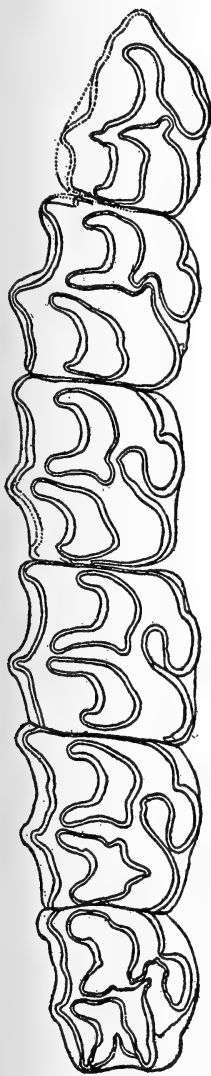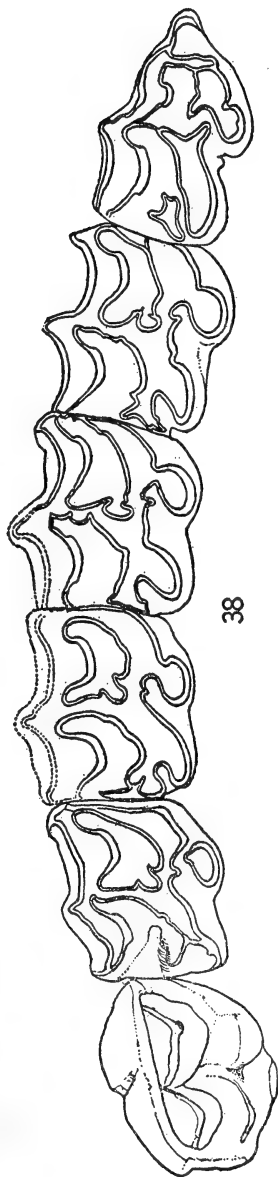
FIG. 36. *Merychippus intermontanus* Merriam. Superior cheek-tooth series, no. 21399, natural size. Barstow Miocene, Mohave Desert, California.
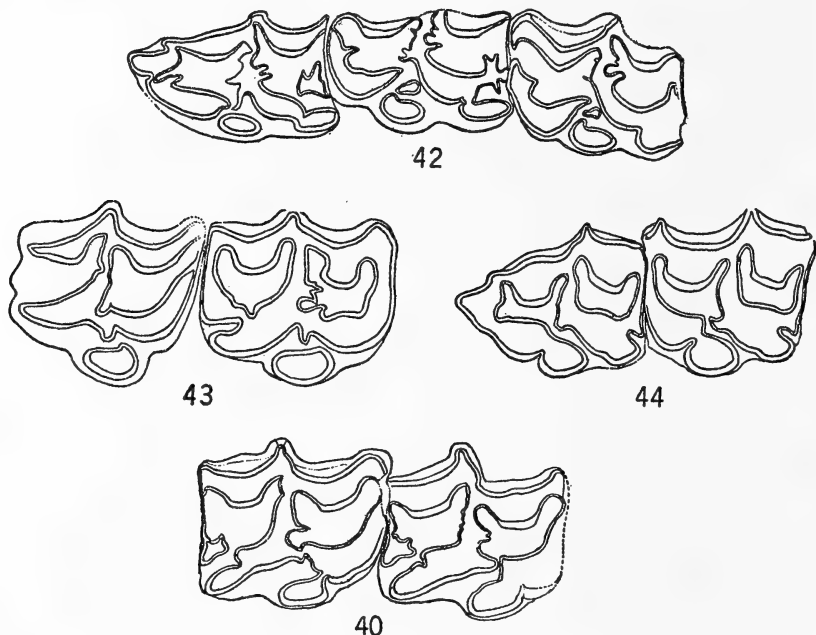FIG. 37. *Merychippus intermontanus* Merriam. Type specimen, P³, no. 21400, natural size. Barstow Miocene, Mohave Desert, California.
FIG. 38. *Merychippus intermontanus* Merriam. Type specimen, superior cheek-tooth series, occlusal view, no. 21400, natural size. Barstow Miocene, Mohave Desert, California.
FIG. 39. *Merychippus intermontanus* Merriam. Type specimen, M², outer view, no. 21400, natural size. Barstow Miocene, Mohave Desert, California.

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Merychippus intermontanus there remains a type to some extent intermediate between these two and closely approaching typical *M. calamarius* (Cope), though the specimens seem rarely if ever to correspond exactly to the characters of that species as shown in Cope's type specimen. This form is described below as *M. calamarius stylodontus*. It is characterized (figs. 43 to 45) by relatively large size, approaching that of *M. intermontanus*, simple protocone

Fig. 40. *Merychippus intermontanus?* Merriam. M^1 and M^2, no. 21409, natural size. Barstow Miocene, Mohave Desert, California.

Fig. 42. *Merychippus sumani?* Merriam. P^2 to P^4, no. 21402, natural size. Barstow Miocene, Mohave Desert, California.

Fig. 43. *Merychippus calamarius stylodontus*, n. var. Type specimen, M^2 and M^3, no. 21410, natural size. Barstow Miocene, Mohave Desert, California.

Fig. 44. *Merychippus calamarius stylodontus*, n. var. P^2 and P^3, no. 22474, natural size. Barstow Miocene, Mohave Desert, California.

nearly circular in cross-section and often separate from the protoconule until the crown is worn down to a height measuring much less than the width of the crown, and relatively simple enamel folds. The crowns are wide and well cemented.

The *M. sumani* group comprises specimens much smaller than those referred to *M. c. stylodontus*, but apparently neither absolutely nor relatively shorter crowned. The enamel bordering the

fossettes is commonly more complicated than in any of the larger *Merychippus* specimens of the Barstow.

The *M. c. stylodontus* form corresponds most nearly to Cope's type specimen of *M. calamarius* in dimensions and in proportions of the upper cheek-teeth in cross-section, but differs from the typical form in the relative simplicity of enamel folds of the walls bordering the fossettes. *M. sumani* resembles typical *M. calamarius* more closely in the folding of the enamel, and possibly in the relative length of the crown. It is considerably smaller than the typ-
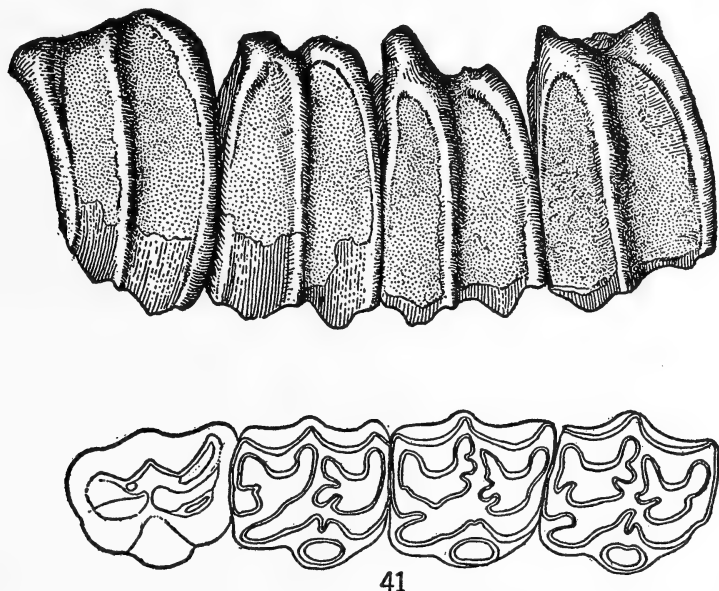
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FIG. 41. *Merychippus sumani* Merriam. Type specimen, P^4 to M^3, no. 21422, natural size. Barstow Miocene, Mohave Desert, California.

ical form and the crowns seem narrower. The apparent difference in width may be due in part to difference in stages of wear of specimens compared, or to method of measurement. The teeth of Cope's type are apparently not in a very advanced stage of wear, but are uncommonly wide. If the stage of attrition is more advanced than the writer has assumed, the complication of the enamel folds becomes a relatively more important character.

The large *Merychippus intermontanus* closely approaches the *M. c. stylodontus* form through the medium of specimens like no. 21409 (fig. 40), in which the protocone unites with the protoconule

in incipient wear and the fossettes have relatively simple borders. The crowns are, however, much larger in *M. intermontanus*.

While it is possible that additions to the material from the Barstow area now available may give sharper definition to boundary lines between the groups of *Merychippus* forms here described, or possibly between groups otherwise organized, it is also possible that fuller collections may serve rather to make separation more diffi-
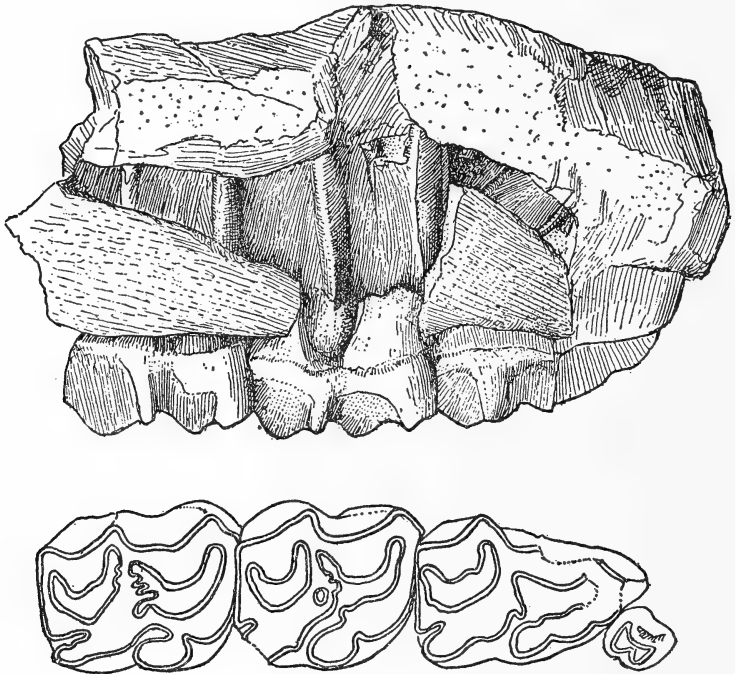
45

Fig. 45. *Merychippus calamarius stylodontus*, n. var. Milk dentition, no. 19816, natural size. Permanent teeth also shown in side view. Barstow Miocene, Mohave Desert, California.

cult. This may be true at least of structure of the cheek-teeth. In the series of *Merychippus* forms of the Barstow fauna as now known, the range of characters very nearly includes the range from *Merychippus* to *Protohippus* and to *Hipparion*. In the large *M. intermontanus* there is no clear separation from *Protohippus* on characters that have been used up to the present time. The cheek-teeth are large, long, heavily cemented, with heavy styles, comparatively simple fossettes, and the protocone unites with the

protoconule in incipient wear.   In the temporary dentition of a large specimen apparently representing *M. intermontanus* the milk molars are long and well cemented.   In the *M. c. stylodontus* type the relatively short crowned character is present with the discrete protocone, and possibly thinner cementation.

In the small *M. sumani* form the characters of *Merychippus* range very near those of typical *Hipparion* as they appear in *H. mohavense* of the Ricardo fauna.   The moderately cemented crowns may attain a length equalling twice the width.   The borders of the fossettes are much crinkled, the protocone is discrete almost to the base and is nearly circular in cross-section.   Characters separating this form from the Ricardo hipparions are seen in the smaller size, relative shortness and greater curvature of crown, more gradual tapering of the mesostyles, and less advanced crinkling of the fossette borders.   These characters in *Hipparion* may be due to continued specialization of the older Barstow form in the direction in which it was already moving.   So far as the cheek-tooth structure is concerned, there appears to be a close relation between the *Merychippus sumani* form of the Barstow fauna and the *Hipparion* species of the Ricardo.

Lower Cheek-Teeth.—The lower molars and premolars of the *Merychippus* forms of the Barstow fauna are somewhat longer crowned than in the species of the Mascall and Virgin Valley beds, and tend generally to be well cemented.   They vary considerably in size, corresponding to the difference between the large and small types of upper molars ranging between *Merychippus intermontanus* and the small *M. sumani* type.

In none of the *Merychippus* specimens from the Barstow fauna has the first lower premolar been observed though it is present in the upper dentition, and is seen as a peg-like tooth in the inferior milk dentition.   In all of the forms of *Merychippus*, the metaconid-metastylid column is shorter anteroposteriorly than in *Hipparion*. The internal groove of this column is narrow and sharp.   The parastylid commonly swings inward to a plane almost even with that of the inner side of the metaconid-metastylid column.   Particularly in the smaller forms an antero-external ridge commonly appears on the protoconid.

The small, inferior, cheek-tooth series which evidently correspond to the *M. sumani* type of upper teeth are generally charac-
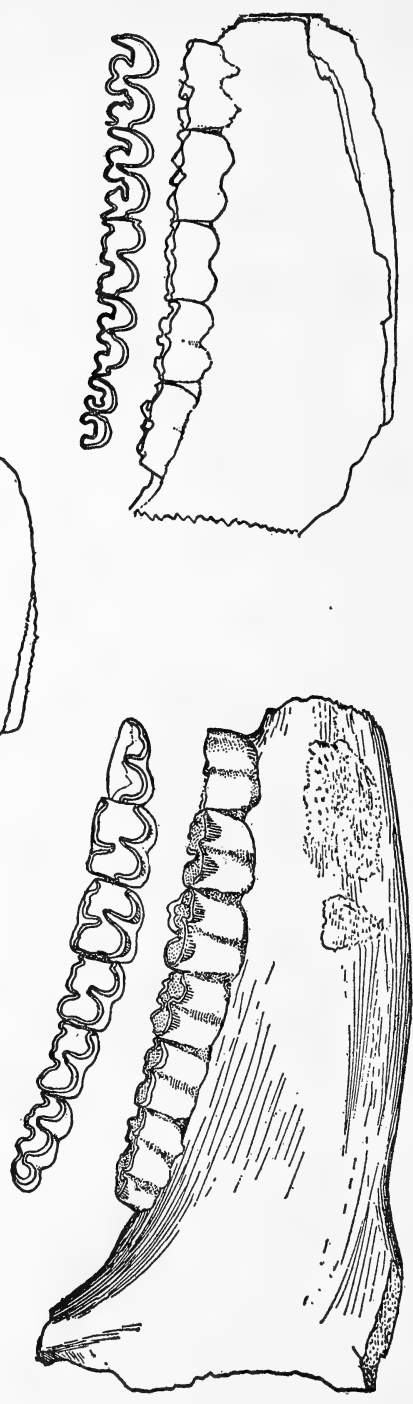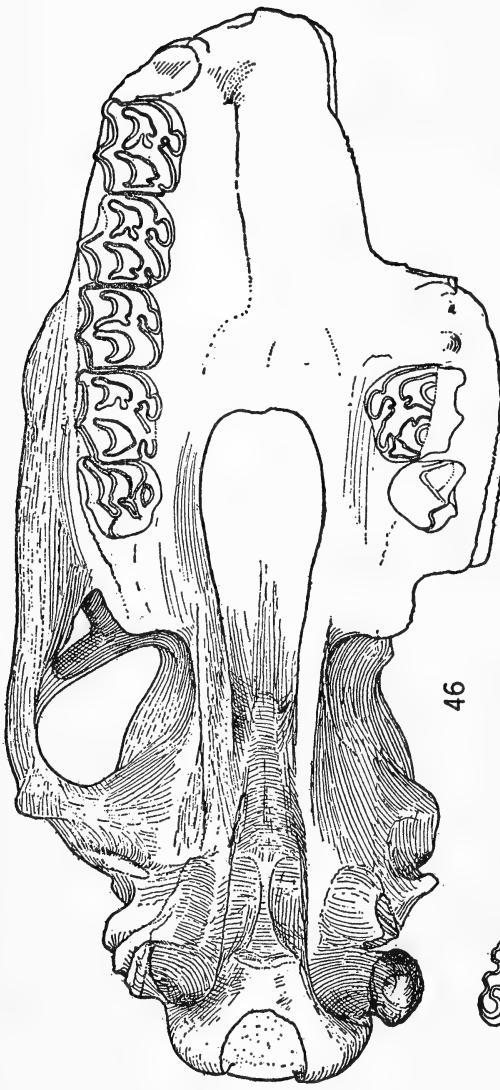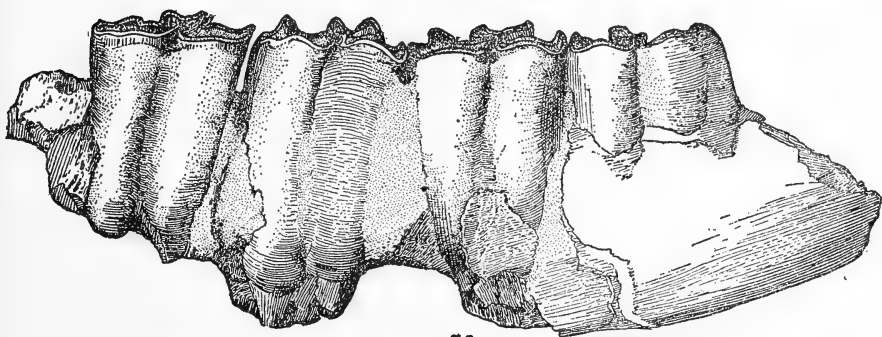
FIG. 46. *Merychippus calamarius stylodontus*, n. var. Skull, ventral view, no. 20039, × ½. Barstow Miocene, Mohave Desert, California.
FIG. 47. *Merychippus calamarius stylodontus*, n. var. Mandible, no. 20039, × ½. Barstow Miocene, Mohave Desert, California.
FIG. 48. *Merychippus intermontanus?* Merriam. Mandible, no. 21228, × ½. Barstow Miocene, Mohave Desert, California.

terized by somewhat shorter crowns than the large form, and by
somewhat less increase in the width of the series in the region of
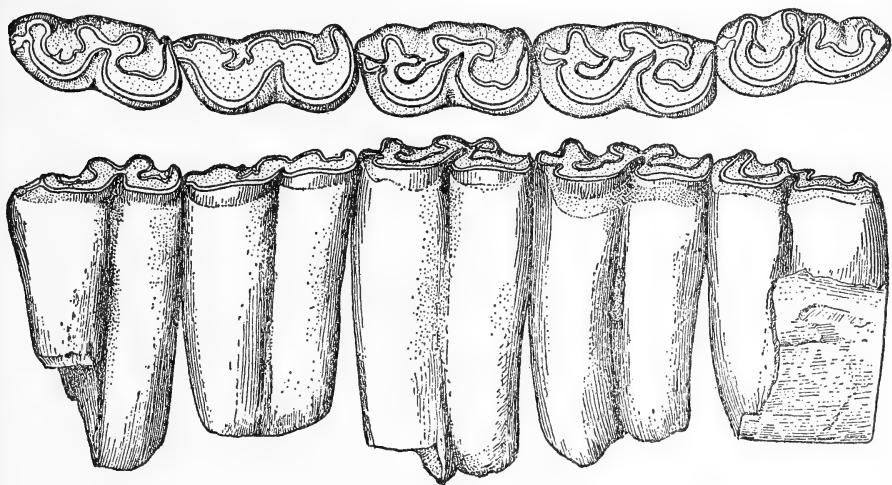
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FIG. 49.   *Merychippus intermontanus* Merriam. P_2 to M_2, no. 21459, $\times \frac{9}{10}$.   Barstow
Miocene, Mohave Desert, California.

FIG. 50.   *Merychippus calamarius stylodontus?*, n. var. P_2 to M_1, no. 19819, $\times \frac{9}{10}$.   Bar-
stow Miocene, Mohave Desert, California.

P_3 and P_4.   In the small forms, the greatest width of the crushing
surface of the lower dentition lies at the posterior end of P_3 and an-
terior end of P_4, as in the large form, but the increase in width in

COMPARATIVE MEASUREMENTS OF SUPERIOR DENTITION OF MERYCHIPPUS FORMS*

| Measurement	Merychippus calamarius, Type specimen	M. c. stylodontus, Type specimen, no. 21411, beginning wear	M. c. stylodontus, no. 21410, moderate wear	M. c. stylodontus, no. 21404, considerably worn	M. c. stylodontus, no. 20039	M. c. stylodontus, no. 21405, beginning wear	M. c. stylodontus? no. 21403, much worn	M. c. stylodontus, no. 21463	M. c. stylodontus, no. 21386	M. intermontanus, Type, no. 21400, moderately worn	M. intermontanus, no. 21399, much worn	M. sumani, Type, no. 21422, moderate wear	M. sumani, no. 21401, much worn	M. sumani? no. 21402, beginning wear	M. sumani, no. 21385, much worn
Length, anterior side I^1 to posterior side M^3									a198						
Length, anterior side P^1 to posterior side M^3															
Length, anterior side P^2 to posterior side M^3	134 mm.								a112	146	139				a107
Length, anterior side P^4									55.7	78.8	73.5				54.8
Length, anterior side M^1 to posterior side M^3	62	56.5			63				a58	67	65.8	57			a52.5
Length of crown, P^3	30	36.5				a32				44	30			a31	a5
Length of crown, M^2				21.5						43	33	32.8			6
P^1, greatest anteroposterior diameter		7													
P^1, greatest transverse diameter									a11						
P^2, anteroposterior diameter	25	24.7	27.5	28.9	22.9	25.9				27.8	a27	22	16	25.4	22.8
P^2, transverse diameter	21	24.7	24.4	24.2	22.3	18.8			20	18.5	23.6	20.8	20	17	22
P^3, anteroposterior diameter	21.5		23.6	23.3	23	23.3	21.4?			24.5	24.2	19	20	22.6	16
P^3, transverse diameter	24		23.4	27.8	23.2	22.8	21.6?		a23	22.7	23.4	19.4	21.9	22.4	17
P^4, anteroposterior diameter	21		23.8	22.2	21	22	19.2			24.9	24.8	20.8	20	20.5	a25.4
P^4, transverse diameter	23			25.9	22.4	20.8	28.1			21	22	18.1	21.6		15.5
M^1, anteroposterior diameter	20				23		20.1			24	26	19.7	17.4		16
M^1, transverse diameter	22				20.7		25		18	24	21.9	15.5	20.6		22
M^2, anteroposterior diameter	21				18.5		21.4			21.7	25		20		21
M^2, transverse diameter	20				19		22.7		19.3	a22	22.7		19.3		
M^3, anteroposterior diameter	?17									a18	19.5				
M^3, transverse diameter									a23						
Length, anterior side I^1 to anterior side P^2									86						
C, anteroposterior diameter								7.3	6.4						
I^1, anteroposterior diameter								8.2	8						
I^1, greatest width								13.2	9.9						
I^2, anteroposterior diameter								7.2	7.5						
I^2, greatest width								13.2	9.7						
I^3, anteroposterior diameter									6.2						
I^3, greatest width								12.8	10.8						

* All measurements without cement. For system of measurements see Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 409, 1913. a, approximate.

COMPARATIVE MEASUREMENTS OF INFERIOR DENTITION OF MERYCHIPPUS FORMS*

	M. c. stylodontus No. 20039 worn	M. c. stylodontus No. 21392 moderately worn	M. c. stylodontus No. 19919 moderately worn	M. intermontanus No. 21459 moderately worn	M. intermontanus No. 21228 well worn	M. sumani? No. 21389
Length, anterior side P₂ to posterior side M₃	....	120.5	....	....	123	....
Length, anterior side P₂ to posterior side P₄	....	60.5	64	75	62	....
Length, anterior side M₁ to posterior side M₃	45.2 mm.	60	....	....	61	57.6
P₂, anteroposterior diameter	....	21.8	20.5	25.1	21.2	a18.5
P₂, transverse diameter	....	10.6	9	10.8	....	....
P₃, anteroposterior diameter	22.2	20.4	22.5	25.1	20.4	18.9
P₃, transverse diameter	11.2	12	10.4	12.2	14.2	....
P₄, anteroposterior diameter	23.5	20	21.8	24.7	20.4	19.8
P₄, transverse diameter	11.6	12.2	10.5	12	14.3	....
M₁, anteroposterior diameter	20.4	18.8	21.6	25.4	18.2	17.5
M₁, transverse diameter	10.6	10.8	9.5	10.1	12.8	....
M₂, anteroposterior diameter	20.9	21.1	....	25.6	18.5	18.2
M₂, transverse diameter	9.4	10	....	9.7	11.5	9.5
M₃, anteroposterior diameter	23.3	21.1	....	....	25	22.1
M₃, transverse diameter	7.8	8	....	....	9.3	8.8
Length of crown, P₄	....	....	38	44	....	....
Length of crown, M₂	....	....	....	a41	....	....
	No. 21569			No. 21776		
I₁, anteroposterior diameter	8	....	....	7.7	....	....
I₁, transverse diameter	10.3	....	....	....	....	....
I₂, anteroposterior diameter	8	....	....	7.7	....	....
I₂, transverse diameter	10.7	....	....	11.6	....	....
I₃, anteroposterior diameter	a6	....	....	a5.7	....	....
I₃, transverse diameter	a10.4	....	....	5.9	....	....
C, anteroposterior diameter	7	....	....	3.9	....	....
C, transverse diameter	6.8	....	....	4.3	....	....

* All measurements without cement. For system of measurements see Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 409, 1913.

a, approximate.

this region seems noticeably less. In such material as is available there is a suggestion that the anteroexternal angle of the protoconid appears more commonly in the small form than in the large.

In a general way, the lower cheek-teeth of *Merychippus intermontanus* (figs. 48, 49) resemble *Protohippus*, and might lead toward *Pliohippus*. Those of the small *M. sumani* form are nearer to *Hipparion* than is the larger type, but do not seem to approach the characters of that genus as closely as do the upper teeth.

Incisors and Canines.—The incisors are well shown in specimen 21463, which is associated with teeth of the *Merychippus c. stylodontus* type. All of the incisors of the upper dentition (figs. 51*a*, 51*b*) are clearly cupped, and cement fills the valleys of the middle incisors to a considerable depth. I_3 is distinctly cupped.
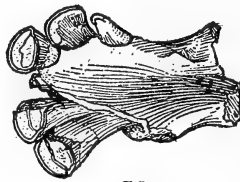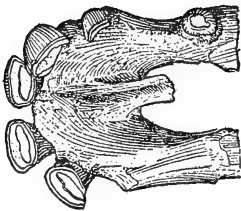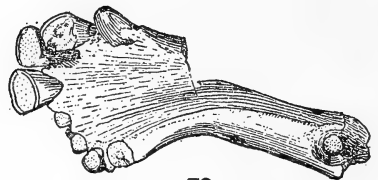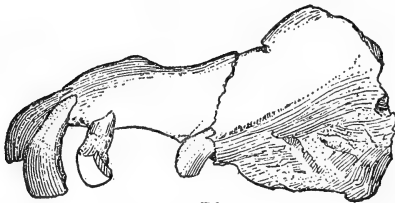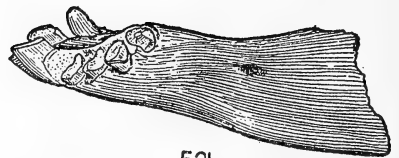
Figs. 51*a* and 51*b*. *Merychippus calamarius stylodontus?*, n. var. Superior incisors and canine, no. 21463, $\times \frac{1}{2}$. Fig. 51*a*, inferior view; fig. 51*b*, lateral view. Barstow Miocene, Mohave Desert, California.

Figs. 52*a* and 52*b*. *Merychippus calamarius stylodontus?*, n. var. Inferior incisors and canine, no. 21569, $\times \frac{1}{2}$. Fig. 52*a*, dorsal view; fig. 52*b*, lateral view. Barstow Miocene, Mohave Desert, California.

Fig. 53. *Merychippus calamarius stylodontus?*, n. var. Inferior incisors and canines, no. 21776, dorsal view, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

Specimen 21776 shows I_1 and I_2 with distinct cupping. On I_3 there is a marked infolding of the posterior wall and an incipient posterior ridge begins to enclose a median pit.

The upper canines of no. 21463 are of moderate size and slightly flattened laterally. In no. 1349, apparently a form of the same specific type, the superior canine is somewhat larger and apparently

is markedly flattened laterally. The inner face shows a median ridge flanked anteriorly and posteriorly by shallow longitudinal grooves.
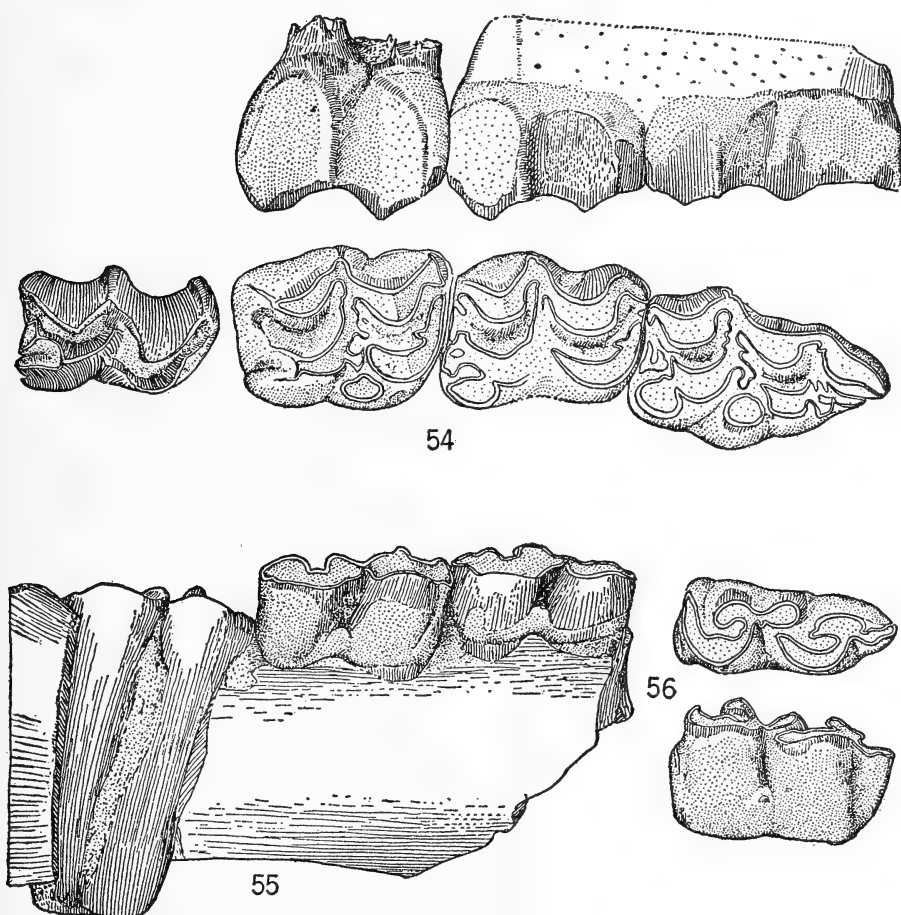
FIG. 54. *Merychippus intermontanus?* Merriam. Superior milk dentition with occlusal view of M^1, no. 21460 natural size. Barstow Miocene, Mohave Desert, California.

FIG. 55. *Merychippus intermontanus* Merriam. Inferior milk dentition with permanent M_1, no. 21398, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 56. *Merychippus intermontanus* Merriam. Dm_3, no. 21461, natural size. Barstow Miocene, Mohave Desert, California.

In a considerable number of specimens exhibiting the symphysial region the lower canine is a large prominent tooth with nearly circular cross-section (fig. 52a) and the root is much larger than that of I_3. In no. 21776 the small inferior canine is situated immedi-

ately behind I₃. The root is approximately one-half as large as that of I₃. This is possibly a female.

Milk Dentition.—The milk teeth of *Merychippus* forms are well shown in a number of specimens from the Barstow beds, but it is not possible to make certain in every case which of the several species is represented.

In specimen 19816 (fig. 45, p. 1164) a complete upper cheek-tooth dentition is shown with the permanent premolars partly formed in the jaw above. The well worn milk teeth have a pattern suggesting *Merychippus calamarius stylodontus.* They are well cemented and the degree of cementation suggests *Protohippus.* The premolars forming in the jaw are large and might represent either *M. c. stylodontus* or *M. intermontanus.*
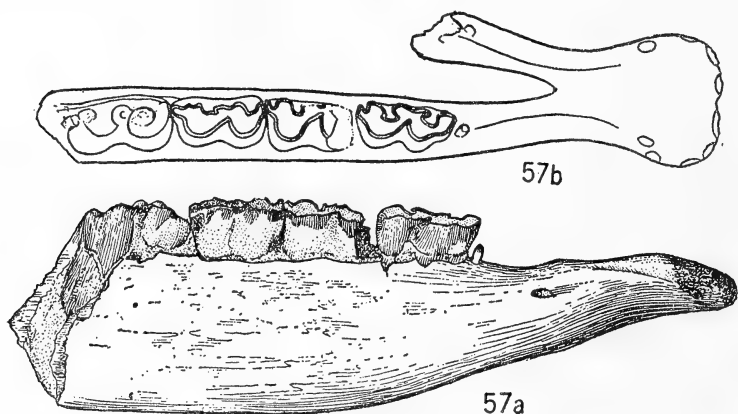
FIGS. 57a AND 57b. *Merychippus sumani?* Merriam. Mandible with milk dentition, no. 20029, × ½. Fig. 57a, lateral view; fig. 57b, dorsal view. Barstow Miocene, Mohave Desert, California.

In no. 21460 the upper milk molars (fig. 54) are somewhat larger than in no. 19816 though of much the same form. In no. 21460 the slightly worn crowns are high and well cemented. They seem as advanced as in *Protohippus.* In no. 21460 M¹ is a large tooth comparable in general to M¹ of *M. intermontanus,* and it is not improbable that this specimen represents that species. The teeth in this specimen differ from those of certain forms referred to *Plio-hippus* in the Ricardo fauna in the more clearly separate protocone and slightly less cementation.

A complete series of lower milk molars (no. 20029, figs. 57a and 57b) represents a relatively small form of the *Merychippus* group.
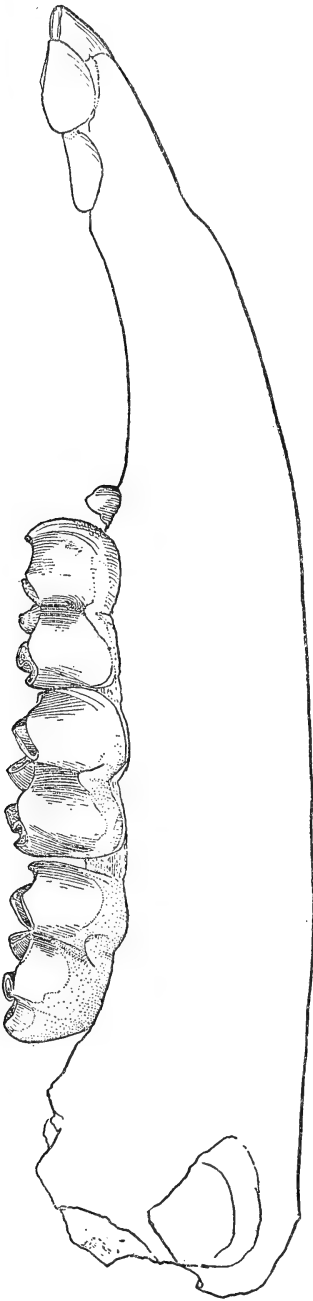
FIG. 58. *Merychippus isonesus* (Cope). Mandible with milk dentition, no. 1678, natural size. Mascall Middle Miocene, John Day Region, Oregon.

FIG. 59. *Merychippus isonesus* (Cope). Inferior milk dentition, occlusal view, no. 1678, natural size. Mascall Middle Miocene, John Day Region, Oregon.

The crowns are about as advanced as in *M. isonesus* of the Mascall, but are more heavily cemented. Dm_1 is a very small peg-like tooth. M_1 is a long tooth. This specimen represents either *M. sumani* or the *M. c. stylodontus* form. The incisors and canines are missing from this specimen. The alveolus for the inferior canine is very small, and is situated close behind I_3.

A lower jaw with milk teeth somewhat larger than in no. 20029 was associated with the upper milk dentition of no. 21460, and probably represents the same specimen. The crowns are high and well cemented, much as in *Protohippus*. This specimen presumably represents *Merychippus intermontanus*.

In all of the lower milk teeth of the *Merychippus* forms of the Barstow fauna the anteroexternal fold on the protoconid, and the external tubercle between protoconid and hypoconid tend to develop.

Comparison with a fine specimen, evidently representing *Merychippus isonesus* (no. 1678, figs. 58 and 59) from the Mascall Miocene in Oregon shows that the difference between the milk molars of the Mascall and Barstow forms is not large. The crowns of the Barstow species are possibly a little longer and the cementation somewhat heavier. So far as known P_1 is larger in the Mascall species. The difference between the temporary teeth seems less than between the permanent cheek-teeth of the Mascall and Barstow forms. As shown in figs. 57*a* and 58 there is a wide difference between the Mascall and Barstow species in the form of the lower jaw. In the Barstow species, the mandible is much higher and heavier than the slender horizontal ramus of the Mascall species.

COMPARATIVE MEASUREMENTS OF MILK DENTITION

	No. 19816	No. 21460	No. 1678 Mascall
Length, anterior side Dm^2 to posterior side Dm^4	*a*77.5 mm.	82.5	*a*71
Dm^1, anteroposterior diameter	10.4	....	....
Dm^1, transverse diameter	7.9	....	....
Dm^2, anteroposterior diameter	30.2	32.5	27
Dm^2, transverse diameter	18.3	21.5	17.5
Dm^2, height of crown	....	....	....
Dm^3, anteroposterior diameter	22.5	24.8	20.5
Dm^3, transverse diameter	21.7	....	18.4
Dm^4, anteroposterior diameter	23.9	25.9	21.3
Dm^4, transverse diameter	21	21.4	....
Dm^4, height of crown	8.5	17	....
M^1, anteroposterior diameter	....	23.8	22.2

COMPARATIVE MEASUREMENTS OF MILK DENTITION—*Continued*

	No. 20029	No. 21461	No. 1678 Mascall	No. 21398
Length, anterior side Dm_2 to posterior side Dm_4	72.5 mm.	a78	66	....
Dm_1, anteroposterior diameter	2.8	....	4.6	....
Dm_2, anteroposterior diameter	24.5	....	22.8	....
Dm_2, transverse diameter	....	....	11.8	....
Dm_3, anteroposterior diameter	....	25.1	21.8	23.7
Dm_3, transverse diameter	11.8	12.5	12.1	....
Dm_4, anteroposterior diameter	24.6	27.9	23	a26
Dm_4, transverse diameter	12.2	a12	11.9	15
Dm_4, height of crown	13	16.8	15	12.5
M_1, anteroposterior diameter	24.5	....	20	a26
M_1, height of crown	a39	....	23	a43

a, approximate.

Skull.—Three specimens show the greater part of the cranium and two others represent portions of the anterior region not well preserved in the better skulls. The several specimens taken together exhibit practically all of the essential characters of the skull. These specimens agree quite closely in comparable measurements and seem all to represent the *Merychippus calamarius* group. No. 20039 (fig. 61), the specimen showing the teeth in the best stage of preservation, seems to belong to the *M. c. stylodontus* type. No. 21385 (fig. 64*a*) possibly belongs to *M. sumani.*

The length of the skull is a little greater than the measurements of *Merychippus* material from the Great Plains region available for comparison, and is greater than in a specimen of *Protohippus sejunctus* (no. 8291, Am. Mus. Nat. Hist.).

The brain case is large, wide, and strongly arched anteroposteriorly in the median line (fig. 60). The anterior slope of the dorsal surface extends downward to the wide, flat or slightly concave frontal area, producing in specimen no. 20039 a peculiar convex form in the parietal region.

The rostral region is rather narrow anterior to the cheek-teeth. Very large lateral or lachrymal fossae originate immediately anterior to the orbits and extend forward as very marked depressions almost to a point opposite P³. In less marked form they may reach almost to the anterior end of the cheek-tooth series. The long narrow nasal elements extend forward over the nasal openings to a point somewhat in advance of the superior canines.

The anterior ends of the large oval orbits are situated above the posterior region of M_3. The zygomatic arch and postorbital bar

are rather slender. The post-glenoid process is of moderate length. The paroccipital process is long and slender.

The occipital condyles are large and wide. The occiput is strongly convex immediately above the foramen magnum, but shows a marked depression, apparently with a median ridge for muscular attachment, just below the marked overhang of the inion.

FIG. 60. *Merychippus*, like *calamarius* (Cope). Reconstruction of skull based on specimens from Barstow Miocene, Mohave Desert, California.

The posterior palatine opening is wide anteriorly, its anterior end being opposite the anterior region of M^2 in no. 21385, an individual of advanced age of the *Merychippus sumani* type. In no. 20039, a younger individual probably of the *M. c. stylodontus* type, the anterior end of the opening is opposite the middle of M^2.

The infraorbital foramen is above the posterior region of P^4 in no. 20039. The postpalatine foramina are opposite the middle of M^2 in the same specimen.

The reconstruction of the skull shown in figure 60 is based in considerable part on specimen 21386, presumably a representative

of *M. c. stylodontus*, with restoration according to the characters of the other skulls available. This restoration may be taken as representing the type like *Merychippus calamarius* in the Barstow fauna.

The form of the skull in the Barstow specimens is in general similar to that of *Merychippus* as known to the writer. In most
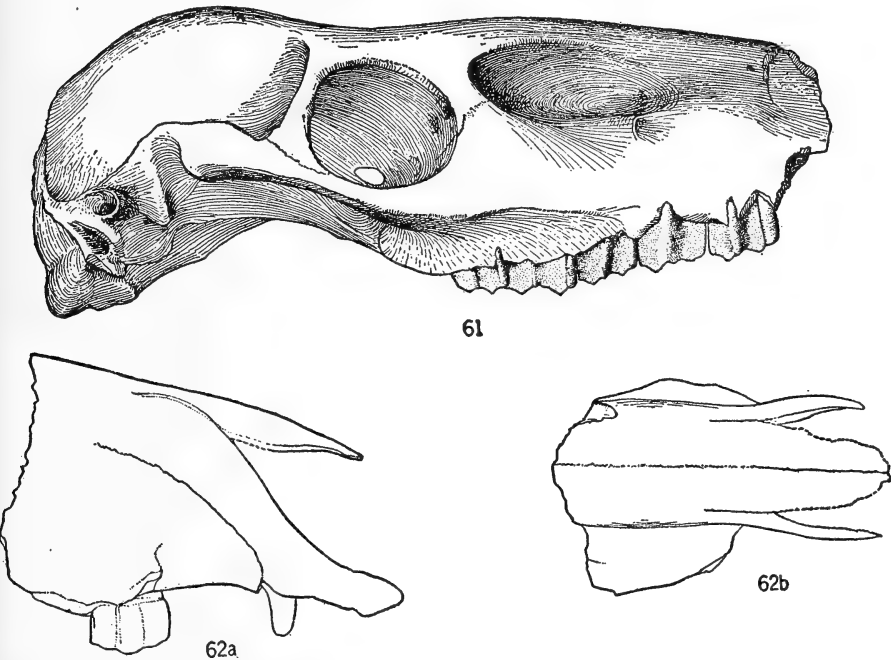
Fig. 61. *Merychippus calamarius stylodontus?*, n. var. Cranium, lateral view, no. 20039, × ⅜; anterior end broken away and occipital region damaged. Barstow Miocene, Mohave Desert, California.

Figs. 62a and 62b. *Merychippus*, sp. Nasal region of cranium, no. 1349, × ⅜. Fig. 62a, lateral view; fig. 62b, dorsal view. Barstow Miocene, Mohave Desert, California.

respects it approaches the type seen in *Protohippus sejunctus* so closely that no generic distinctions are apparent. Such differences as exist are apparently of specific value.

MEASUREMENTS OF SKULL

	No. 20039	No. 21386	No. 21387	No. 21385
Length, anterior end premaxillary to posterior end occipital condyles............	....	336 mm.		....
Length, anterior end P² to anterior end premaxillary........................	....	82	....	....

MEASUREMENTS OF SKULL—*Continued*

	No. 20039	No. 21386	No. 21387	No. 21385
Length, anterior side of orbit to anterior end of premaxillary	....	a194	...	....
Length, anterior side M^1 to posterior side of occipital condyles	199 mm.	196	...	196
Length, anterior side M^1 to anterior end of premaxillary	....	138	...	....
			crushed	
Width, between inner sides of M^1	52.5	....	a46	44
Least width between orbits	96	a90	...	a83
Least width across nasal ridge above lachrymal fossae	a31	crushed 25.3	a36	....
Greatest width across zygomatic arches	a142	....	...	120
Greatest width of occipital condyles	52.5	a57	...	51.8
Greatest anteroposterior diameter of orbit	49.5	....	...	a50

	No. 21389	No. 21228			
Height of mandible below anterior end of M_2	47	51	....	...	....

	No. 20029				
Height of mandible anterior end of M_1.	41	....	....	...	....

a, approximate.

The mandible is not shown complete in any specimen. In no. 20029 (figs. 57a and 57b), a young individual with M_1 not yet in function, the horizontal ramus is seen to be much higher than in a young specimen of *Merychippus isonesus* from the Mascall Miocene. The symphysial region is not greatly widened, and the very small canine is close behind I_3.

A lower jaw (fig. 47) associated with the skull no. 20039 does not show the outlines of the ramus. In no. 21228 the form of the mandible in the adult is seen to be much as in the young specimen represented in no. 20029 (fig. 57a).

Limbs.—Large numbers of skeletal parts found in the beds of the Barstow syncline represent a *Merychippus* species corresponding approximately to *M. calamarius* in stage of development and in size.

The range of variation in the material extends from elements representing small forms near the size of specimens of *Merychippus isonesus* of the Mascall up to elements from individuals evidently about double the size of the smaller type. In the absence of good associated skeletal material it is not possible to make a thoroughly satisfactory determination of the systematic position of the species represented by the skeletal elements, but it is reasonable to assume that the smallest represent *Merychippus sumani* as known from the
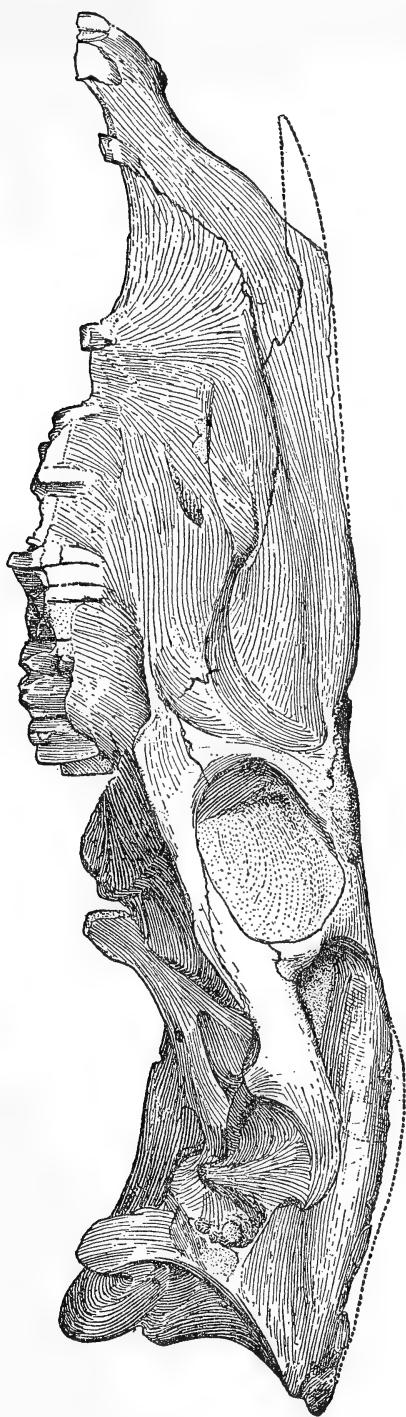
FIG. 63. *Merychippus calamarius stylodontus?*, n. var. Cranium, lateral view, no. 21386,
× ½. Barstow Miocene, Mohave Desert, California.

1179
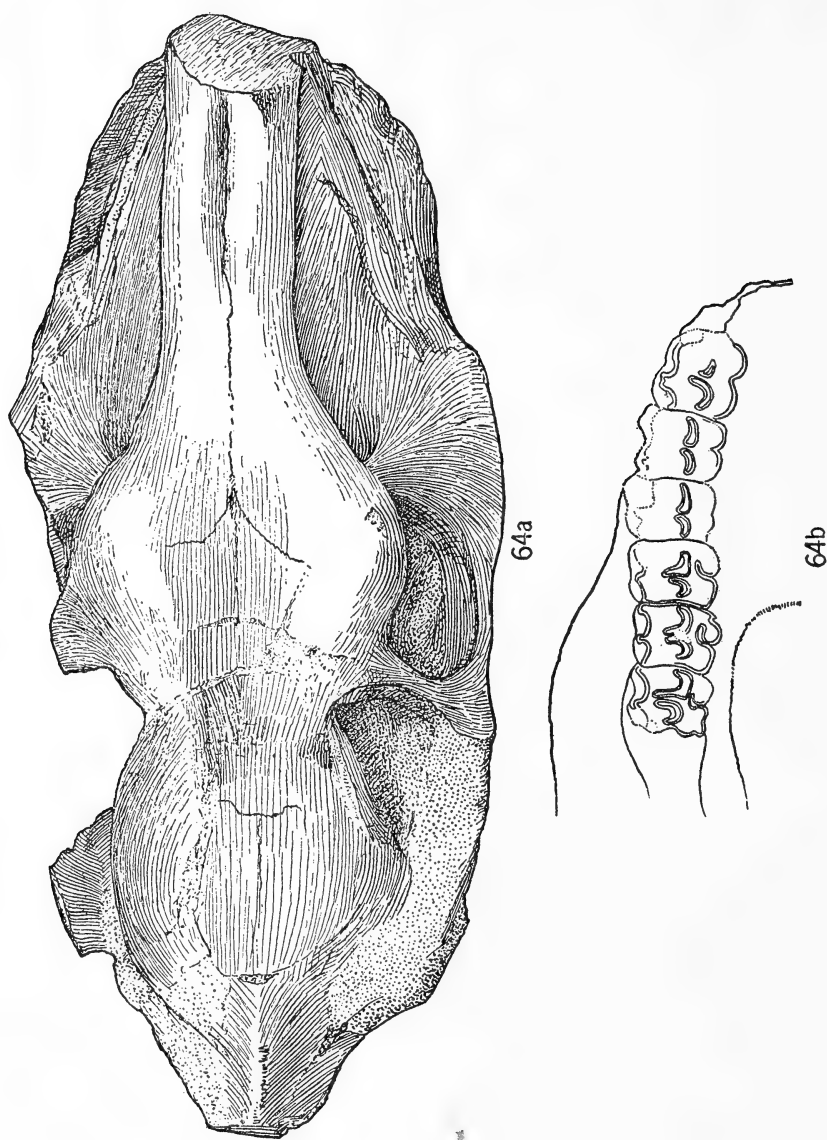
Figs. 64a AND 64b. *Merychippus*, sp. Cranium, no. 21385, × ½. Fig. 64a, dorsal view; fig. 64b, view of palate with teeth. Barstow Miocene, Mohave Desert, California.
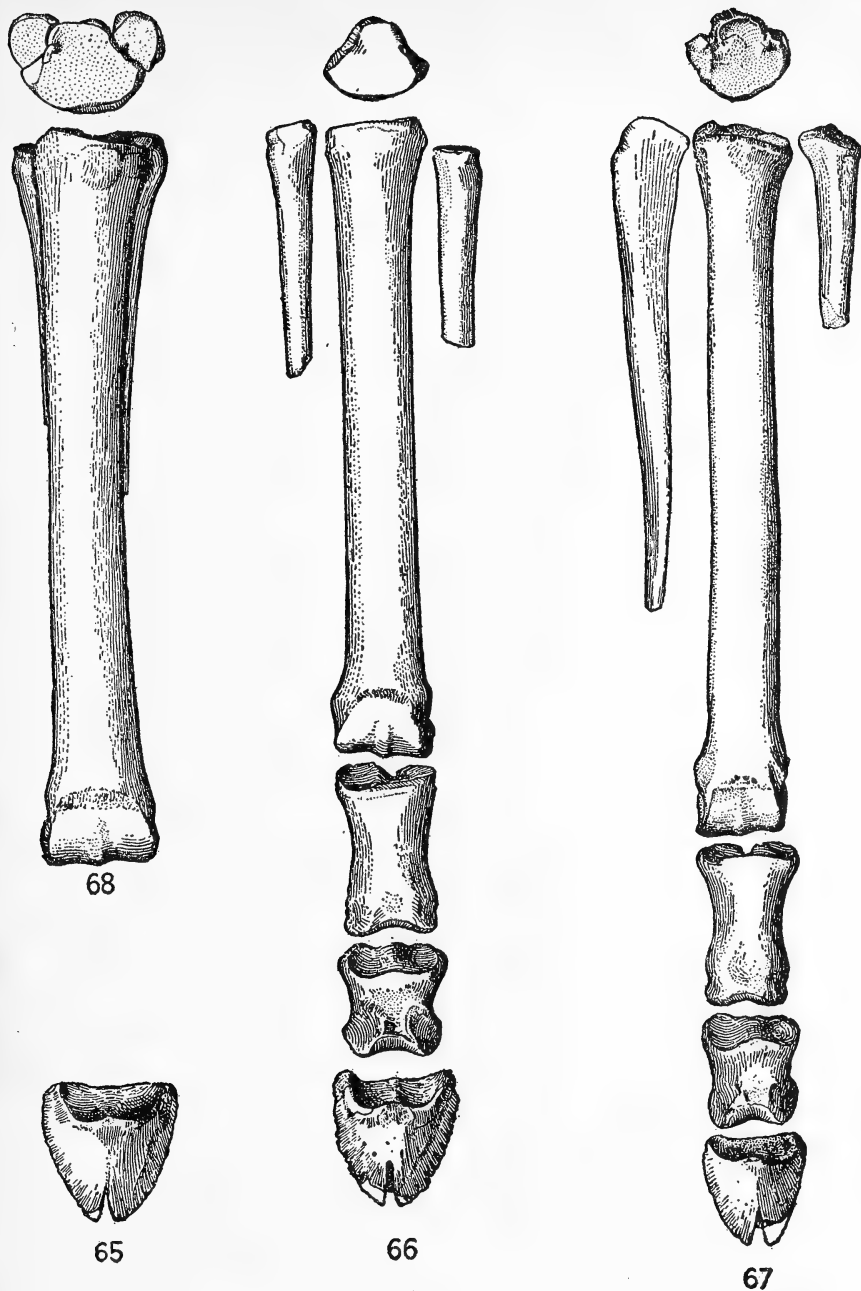
FIG. 65. *Merychippus*, sp. Ungual phalanx, no. 23131, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 66. *Merychippus*, sp. Third metacarpal and digit with proximal ends of metacarpals 2 and 4, no. 22372, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 67. *Merychippus*, sp. Third metatarsal and digit with fragments of metatarsals 2 and 4, no. 19817, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 68. *Merychippus*, sp. Third metacarpal with splint bones, no. 21470, × ½. Barstow Miocene, Mohave Desert, California.

dentition, and that the largest specimens are from the *M. inter-montanus* type.

FIG. 69. *Merychippus*, sp. Third metatarsal, no. 21407, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 70. *Merychippus*, sp. Distal end of third metatarsal with first phalanx, no. 21468, × ½. Barstow Miocene, Mohave Desert, California.

In general the type of foot structure is similar to that of the genus *Merychippus* as seen in *M. isonesus*. The metapodials are slender, the lateral digits small and scarcely functional. The hoofs

of digit III are narrow, and with a marked terminal cleft. The narrow astragalus has a deep subacute trochlear groove.

The abundant proximal phalanges of digit III (figs. 66 and 67) are much more slender than those of *Hypohippus* (fig. 29) and show a marked median constriction. There is a suggestion of less flattening and more distinct rounding of the shaft than in a number of specimens presumably representing *Merychippus isonesus* from the Virgin Valley Miocene. The groove for the trochlear ridge of the metapodials is commonly not well marked at the anterior side of the proximal articular face; but in a few of the largest specimens (fig. 68) it is strongly marked on the anterior side corresponding to the development of the metapodial keel.

The second phalanges of digit III are easily distinguished by their narrower form from the wide, relatively short phalanges of *Hypohippus*.

The ungual phalanges of digit III of even the smallest form (fig. 67) in the Barstow fauna are relatively somewhat wider than in one perfect specimen of a Merychippus-like horse from the Mascall available for comparison, but have nearly the same size and proportions as another Mascall specimen. The difference between the smallest and largest forms in the Barstow collection is mainly one of size. In all of the specimens the anterior end is subacute, with the terminal cleft well marked. The posterolateral wings project slightly behind the inferior margin of the proximal articular face.

Compared with casts of the feet of *Protohippus sejunctus* from the American Museum, the largest ungual phalanges in the Barstow collections have nearly the same size, but seem to show slightly smaller lateral wings, and are possibly a little higher posteriorly.

MEASUREMENTS OF METAPODIAL III

	Length	Least transverse diameter of shaft	Greatest transverse diameter of proximal end of shaft	Greatest transverse diameter of distal end of shaft
Anterior, no. 22372	165.2 mm.	17	25	25.5
Posterior, no. 19817	180.5	17.3	23.6	24.2
Posterior, no. 23130	183	16	25.4	25

Metapodial III of the *Merychippus* species of the Barstow fauna varies considerably in size, but the general outlines of the shaft do not vary greatly in either front or hind limb. The distal keel is well developed in all specimens. In some individuals the keel is scarcely visible on the anterior side of the distal articular face of even the posterior metapodial III, but careful examination will show a faint ridge reaching the proximal end of the anterior face. On some of the large specimens, as in no. 21269, the keel is strongly marked up to the proximal end of the anterior side of the distal articulation.

In metacarpal III the angle between the magnum and unciform facets ranges from near 112° to a little more than 121°. In the smaller, more slender specimens there appears a tendency toward a sharper angle than in the larger individuals. There are, however, small specimens in which the angle is 121°. It is probable that the smaller, more slender specimens of metacarpal III with the more acute magnum-unciform angle represent *Merychippus sumani*. The larger, heavier specimens with the tendency toward a wider angle presumably belong to *M. intermontanus*. In metatarsal III the cuboid facet may be nearly transverse to the long axis of shaft. It is commonly separated from the ectocuneiform facet by a sharp ridge, but the larger part of the cuboid facet may be inclined away from the ectocuneiform facet only a few degrees. In most specimens there appears to be no facet for the mesocuneiform. In others, as in no. 21206, a distinct mesocuneiform articulation lies almost in the plane of the ectocuneiform surface.

The astragalus in all of the *Merychippus* specimens shows a deep, narrow trochlear groove. The cuboid facet is well developed. The astragali vary much in size as shown in figures 77 to 79, and may well represent two or more specific types ranging from *M. intermontanus* to *M. sumani*.

The calcaneum, as shown in many specimens, seems not to differ particularly from that in other *Merychippus* forms.

Metacarpals II and IV are shown in a number of specimens (figs. 66, 68, and 72). They are quite small in comparison with metacarpal III. Compared with a cast of the foot of *Protohippus sejunctus* kindly furnished by the American Museum they are not relatively larger, and the fourth metacarpal seems somewhat smaller. Very small lateral facets are present on both metacarpal
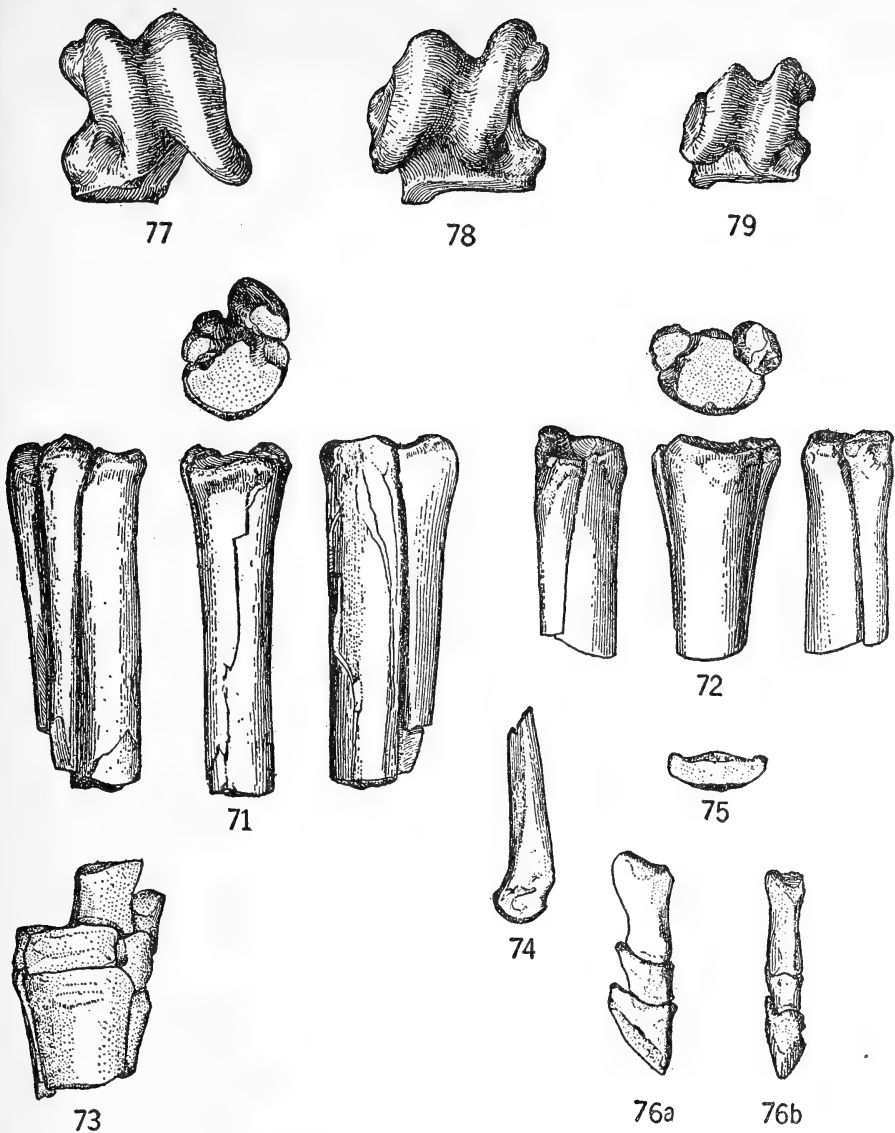
FIGS. 71 TO 79. *Merychippus*, sp., from Barstow Miocene, Mohave Desert, California.

FIG. 71. *Merychippus*, sp., metatarsals two to four, no. 22479, × ½.

FIG. 72. *Merychippus*, sp. Metacarpals two to four, no. 22370, × ½.

FIG. 73. *Merychippus*, sp. Carpus with proximal ends of metapodials, no. 21570, × ½.

FIG. 74. *Merychippus*, sp. Distal end of lateral metapodial, no. 22475, × ½.

FIG. 75. *Merychippus*, sp. Lower sesamoid or navicular, third digit, no. 22476, proximal view, × ½.

FIGS. 76a AND 76b. *Merychippus*, sp. Lateral digit, no. 22490, × ½. Fig. 76a, lateral view; fig. 76b, anterior view.

FIG. 77. *Merychippus*, sp. Astragalus, no. 23122, × ½.

FIG. 78. *Merychippus*, sp. Astragalus, no. 23123, × ½.

FIG. 79. *Merychippus*, sp. Astragalus, no. 23124, × ½.

II and IV. Judging by the size of these lateral facets, the rudiments of metacarpals I and V must have been smaller than the small nodules seen in *P. sejunctus*.

The lateral metapodials of the hind foot (figs. 67 and 71) are, so far as known, not larger and possibly smaller than in *Protohippus sejunctus*. The complete form is not known but in at least one case, as shown in figure 67, the distal region of the lateral metatarsal is much reduced.

All of the specimens representing distal ends of the lateral metapodials found in the Barstow are small and slender (fig. 74). The lateral phalanges known are also small (figs. 76*a* and 76*b*). All of the evidence available shows that the lateral toes were small.

The variations shown above between the large and small forms of metapodials may well be comparable to the difference between *Merychippus intermontanus* and *M. sumani*.

Certain forms of foot structure seen in the *Merychippus* types of the Barstow fauna might be transformed into those of horses in the Ricardo, without extraordinary modifications.

MERYCHIPPUS INTERMONTANUS Merriam

Merychippus intermontanus, n. sp. Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 50, 52, figs. 2, 3, 1915.

Type specimen, no. 21400. An upper cheek-tooth dentition from locality 1401 in the Barstow Miocene of the Mohave Desert, California.

Cheek-teeth large (figs. 36–39); crowns long, strongly curved, heavily cemented. Protocone of upper cheek-teeth uniting early with protoconule. Enamel walls bordering the fossettes comparatively simple.

MERYCHIPPUS CALAMARIUS STYLODONTUS, n. var.

Type specimen an upper cheek-tooth dentition, no. 21410, from locality 2057, in the Barstow Miocene of the Mohave Desert, California.

Upper cheek-tooth dentition (figs. 43–46) much as in typical *Merychippus calamarius* (Cope). Crowns larger and relatively shorter than in *M. sumani*. Protocone nearly circular in cross-section and often separate from protoconule until the crown is reduced to a height measurement less than the width. Enamel folds bordering the fossettes apparently simpler than in typical *M. calamarius*.

MERYCHIPPUS SUMANI Merriam

Merychippus, near *calamarius*. Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 6, p. 168, pl. 29, figs. 1*a*–1*c*, 1911.
Merychippus sumani, n. sp. Merriam, J. C., Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, pp. 49, 50, fig. 1, 1915.

Type specimen, no. 21422.   Barstow Miocene, Mohave Desert, California.

Upper cheek-teeth (fig. 41) much smaller than in typical *Merychippus cala-marius* or in *M. intermontanus*.   Crowns of cheek-teeth considerably elongated, markedly curved, and well cemented; height of the crowns often equal approximately to twice their width.   Protocone round, tending toward circular form in cross-section, and discrete up to a stage of very advanced wear.   Enamel bordering the fossettes commonly more complicated than in any of the larger *Mery-chippus* forms of the Barstow Miocene.

<div align="center">PROTOHIPPUS?, or PLIOHIPPUS?, sp.</div>

A single upper molar, no. 21423 (figs. 80 and 81), represents a form apparently more advanced than the type of *Merychippus*
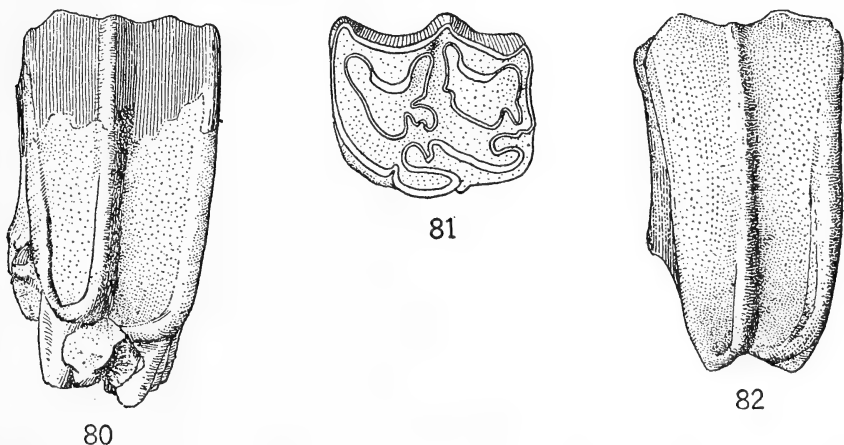
FIGS. 80 AND 81.   *Protohippus?* or *Pliohippus?*, sp.   Superior cheek-tooth, no. 21423. Fig. 80, outer view; fig. 81, occlusal view.   Barstow Miocene, Mohave Desert, California.

FIG. 82.   *Protohippus* or *Pliohippus?*, sp.   Superior cheek-tooth, no. 21424, natural size. Barstow Miocene, Mohave Desert, California.

intermontanus.   It is closely allied to *Protohippus*, but better material might indicate its affinity with *Pliohippus*.   This specimen was associated with the type specimen of *M. intermontanus* from locality 1401 in the Barstow syncline.

The characters of this tooth are near those of *M. intermontanus*, but it differs from that form in greater width and its much more compressed and anteriorly longer protocone.

The form represented by no. 21423 (figs. 80, 81) may be a species distinct from *M. intermontanus* or may be a more advanced stage of that species.   Specimen no. 21423 represents the maximum of advance of the Equidae in the Barstow fauna.   It differs from all

three of the *Pliohippus* forms of the Ricardo.   It is smaller, and less advanced than *Pliohippus fairbanksi*. It differs from *P. tantalus* in the smaller fossettes, and is also somewhat smaller and apparently less advanced.   A single tooth from the Ricardo, representing a form near *Pliohippus mirabilis* is smaller in cross-section than no. 21423 from the Barstow fauna, but the Ricardo specimen is considerably worn and may originally have been the longer crowned and more progressive of the two.

Two other upper cheek-teeth, nos. 21424 and 21425, from localities in the Barstow represent forms near that seen in no. 21423 described above.   No. 21424 (fig. 82) is little worn and is the longest molar found in the Barstow.   The pattern of the crown and of the protocone, so far as known, suggests that of no. 21423.   No.

FIG. 83.   *Prosthennops?*, sp.   Astragalus, no. 22469, natural size.   Barstow Miocene, Mohave Desert, California.

21425 is a much worn tooth and may represent *Merychippus intermontanus*.

MEASUREMENTS

	No. 21423	No. 21424	No. 21425
M¹, anteroposterior diameter	24.2 mm.	a23.5	24
M¹, transverse diameter	23.8	a19	24
M¹, height of crown	39	42.6	37

a, approximate.

The large protohippine horses of the Barstow fauna represented in *Merychippus c. stylodontus*, *M. intermontanus*, and the *Protohippus* or *Pliohippus* described above, are antecedent types such as we might expect to find in the ancestors of the Ricardo and Etchegoin *Protohippus* and *Pliohippus* species.   *Pliohippus fairbanksi* of the Ricardo fauna and *P. coalingensis* of the Etchegoin may either or both be derivations of *Merychippus intermontanus*

of the Barstow.   *Pliohippus tantalus* is as yet imperfectly known, but may be a derivative of a form near one of the Barstow types.

SUIDAE

A single astragalus of a suilline form, no. 22469 (fig. 83), from locality 1398 in the Barstow beds represents a dicotyline form, but a generic determination seems doubtful.   This specimen shows the presence in this fauna of the peccary-like forms so well represented elsewhere in the American Miocene.

OREODONTIDAE

MERYCOCHOERUS? BUWALDI, n. sp.

Type specimen, no. 21350, an upper dentition from locality 2057, Barstow beds, Barstow syncline, north of Barstow, California.

Fragmentary oreodont remains representing a form near *Mery-cochoerus* were found sparingly by Baker in the Barstow region in 1911.   In 1913 Buwalda and Mourning found more abundant material showing a complete upper cheek-tooth series, and a considerable part of the lower dentition.

This species is near *Merycochoerus* in general characters of the dentition and skull.   It is at least as advanced as that genus in specialization of the premolars and in relative proportions of the molar and premolar series.

Only small portions of the skull are present in the type specimen, no. 21350 (fig. 84).   The anterior portion of the base of the zygomatic arch arises above M^1.   Anterior to the root of the zygomatic arch the maxillary appears to be somewhat flattened superiorly in a plane nearly parallel with the palate.   The infraorbital foramen is situated at the posterior end of this flattened area, and above the anterior half of M^2.   In specimen 21485 (figs. 85*a* and 85*b*), the base of the zygomatic arch is shown more satisfactorily.   The lower jaw as seen in several quite fragmentary specimens has approximately the form shown in *Merycochoerus*. It is high anteriorly and on one specimen seems to increase in height rapidly below the posterior molars.   It does not seem to show the unusual elevation of the posterior region of the mandible exhibited in *Pronomotherium*.

The dentition is characterized by height of the crowns of the cheek-teeth, relatively great length of the molar series compared
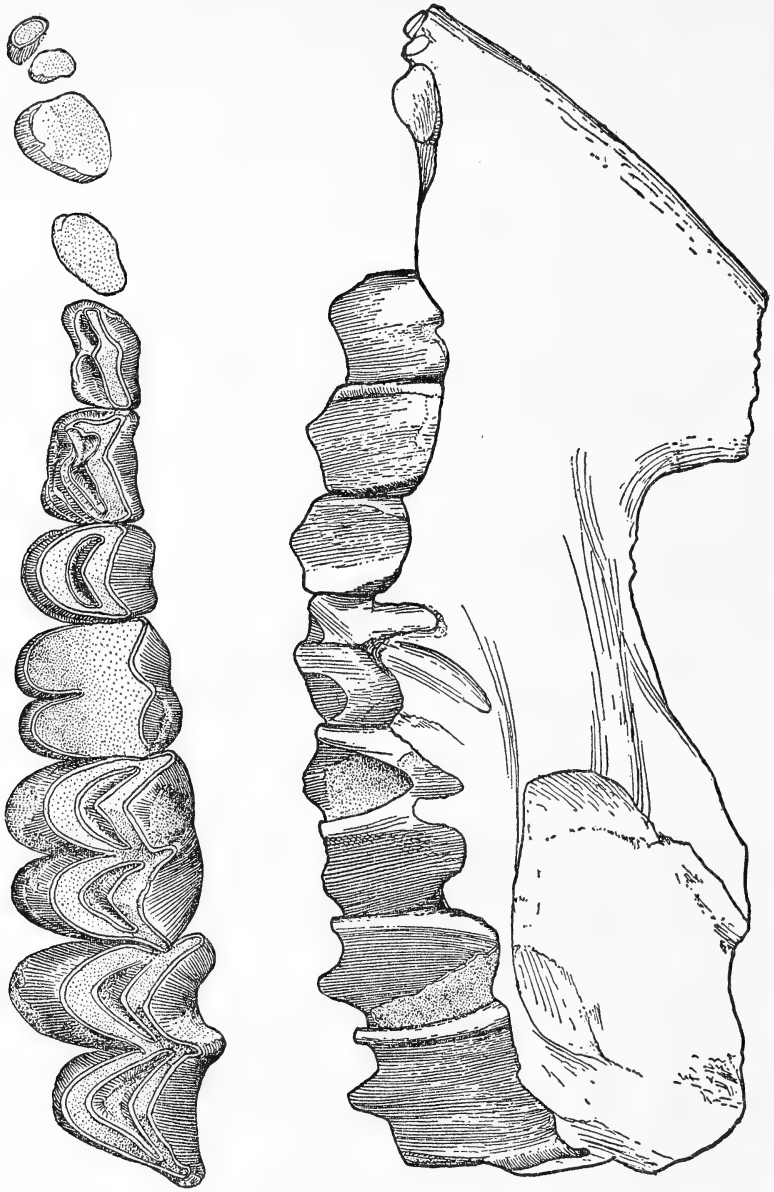
Fig. 84. *Merycochoerus? buwaldi,* n. sp. Skull fragment with superior dentition, type specimen, no. 21350, natural size. Barstow Miocene, Mohave Desert, California.

with the premolars, advanced specialization of the premolars, and a tendency to crowding of the premolars anteriorly.

The stage of complication of the premolars is near that of *Mery-*
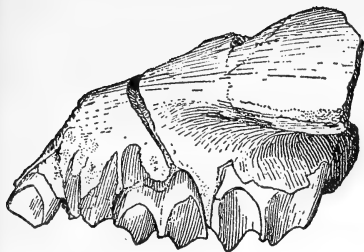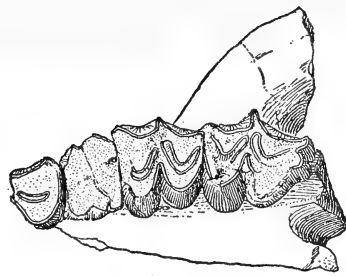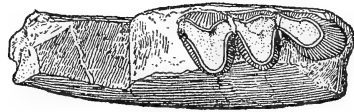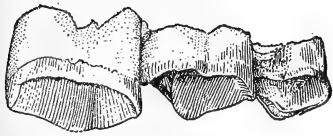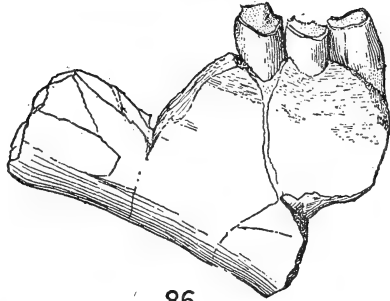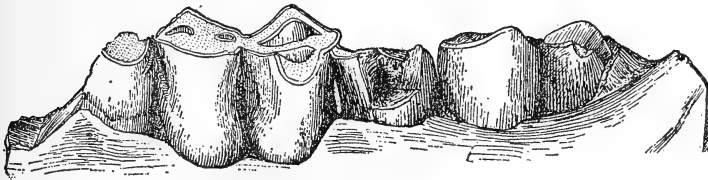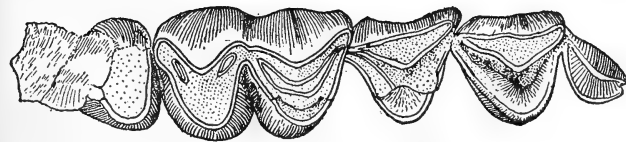
FIGS. 85a AND 85b. *Merycochoerus? buwaldi*, n. sp. Skull fragment with P⁴ to M³, no. 21485, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 86. *Merycochoerus? buwaldi*, n. sp. Fragment of mandible, outer and dorsal views, with M³, no. 21485, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 87. *Merycochoerus? buwaldi*, n. sp. Inferior premolars, no. 21354, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 88. *Merycochoerus? buwaldi*, n. sp. M₁ to M₃, no. 21487, natural size. Barstow Miocene, Mohave Desert, California.

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cochoerus proprius, and not more advanced than in that species. In the Barstow species the elongation of the cheek-tooth crowns seems to have advanced farther and the external anterior and posterior styles in P³ and P⁴ seem better developed than in *M. proprius*. In the Barstow form the outer faces of P³ and P⁴ are nearly flat with a faint longitudinal rib, which the writer has not seen on *M. proprius*.

There are suggestions of external paracone and metacone ribs on the upper molars of the type specimen of *M. buwaldi*. These ribs are not clear on no. 21485.

On P² of *M. proprius* there is a small anterior pocket in the enamel which does not appear on the only Barstow specimen showing this tooth. An internal basal cingulum is clearly shown
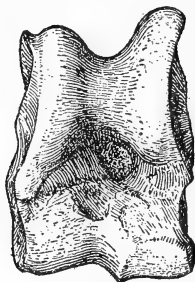
Fig. 89.   *Merycochoerus? buwaldi*, n. sp.?   Astragalus, no. 21486, natural size.   Barstow Miocene, Mohave Desert, California.

on the upper premolars of the Barstow form. It is faint or absent on the upper molars.

The upper canine is triangular in outline. The upper incisors are very small.

In the lower dentition the degree of complication is approximately as in *M. proprius*, and not more advanced. P₁ is relatively smaller, or the other premolars relatively larger than in *M. proprius*.

P₃ and P₄ of *M. buwaldi* are both less complicated than in *M. rusticus* of the Pawnee Creek beds of Colorado (Am. Mus. Nat. Hist., no. 9115, now in collections of University of California). The anterointernal fold is more prominent on both P₃ and P₄ in *M. rusticus* than in the Barstow species. The internal cingula are strong on the premolars. The external cingula are fairly marked. The lower molars have moderately elongated crowns on the speci-

mens available for study. There are faint internal ribs on the metaconid and entoconid columns.

A single astragalus, no. 21486 (fig. 89), from the Barstow may represent an oreodont form.

MEASUREMENTS OF SKULL AND DENTITION

	No. 21350	No. 21485
Length, anterior side of superior canine to posterior side of M^3..	142 mm.	....
Length of superior molar-premolar series..................	128.5	....
Length of superior premolar series.......................	53.5	....
Length of superior molar series..........................	75	....
I^2, greatest transverse diameter.........................	5.3	....
I^3, greatest transverse diameter.........................	7.4	....
Superior canine, greatest transverse diameter..............	14.7	....
P^1, anteroposterior diameter...........................	a12.2	....
P^2, anteroposterior diameter...........................	15.8	....
P^2, transverse diameter................................	10.5	....
P^3, anteroposterior diameter...........................	14.8	....
P^3, transverse diameter................................	14	....
P^4, anteroposterior diameter...........................	13	12.8
P^4, transverse diameter................................	17.8	16.4
M^1, anteroposterior diameter...........................	19.6	15
M^1, transverse diameter................................	22	20.6
M^2, anteroposterior diameter...........................	26.3	24
M^2, transverse diameter................................	26.4	24
M^3, anteroposterior diameter...........................	34.5	29.7
M^3, transverse diameter................................	27.8	30.7
	No. 21354	
P_2, anteroposterior diameter...........................	12.8	....
P_2, transverse diameter................................	6	....
P_3, anteroposterior diameter...........................	15.5	....
P_3, transverse diameter................................	10.4	....
P_4, anteroposterior diameter...........................	17.2	....
P_4, transverse diameter................................	12.1	....
	No. 21487	No. 21485
M_2, anteroposterior diameter...........................	24.8	a24
M_2, transverse diameter................................	16.1	a16
M_3, anteroposterior diameter...........................	37.2	38
M_3, transverse diameter................................	13.2	17.2

a, approximate.

CAMELIDAE

Remains of camels are among the most common fossils found in the Barstow beds. Unfortunately the teeth do not resist destructive processes as well as those of the horses, and in absence of complete skeletal material little but scattered foot bones remain for study. Almost the only basis for comparative study of the
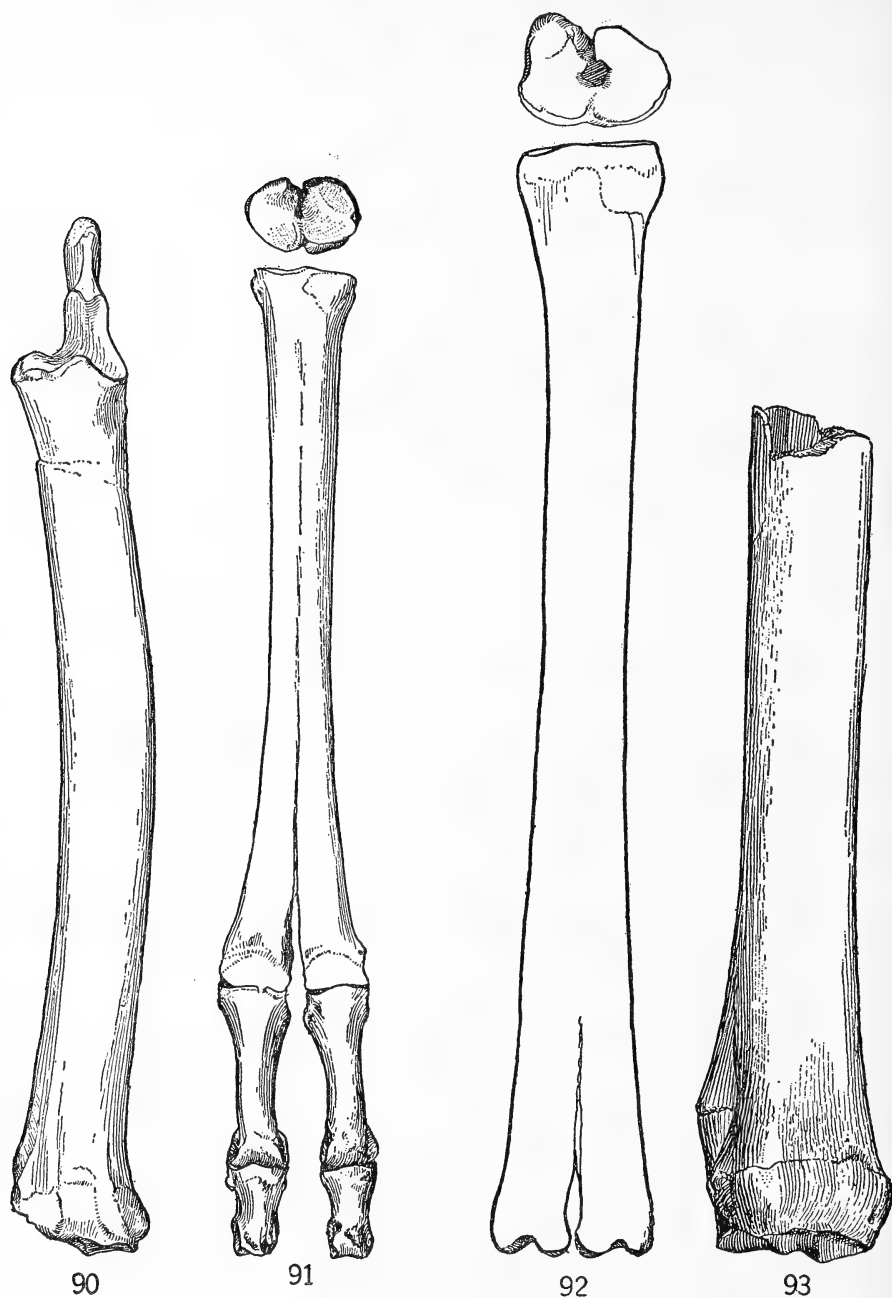
FIGS. 90 TO 93. Camel remains from Barstow Miocene, Mohave Desert, California.

Fig. 90, *Procamelus*, sp., radius and ulna, no. 22492, × ¼; fig. 91, *Procamelus*, sp., cannon bone and phalanges, anterior limb, no. 22491, × ¼; fig. 92, *Alticamelus?*, sp., cannon bone, no. 21552; × ¼; fig. 93, *Alticamelus?*, sp., distal half of radius, no. 22493, × ¼.

camels seems to be furnished by the astragali.   Of these there are at least four types, graded according to form and size.   One is a small form (compare fig. 98), of which the astragalus is a little more
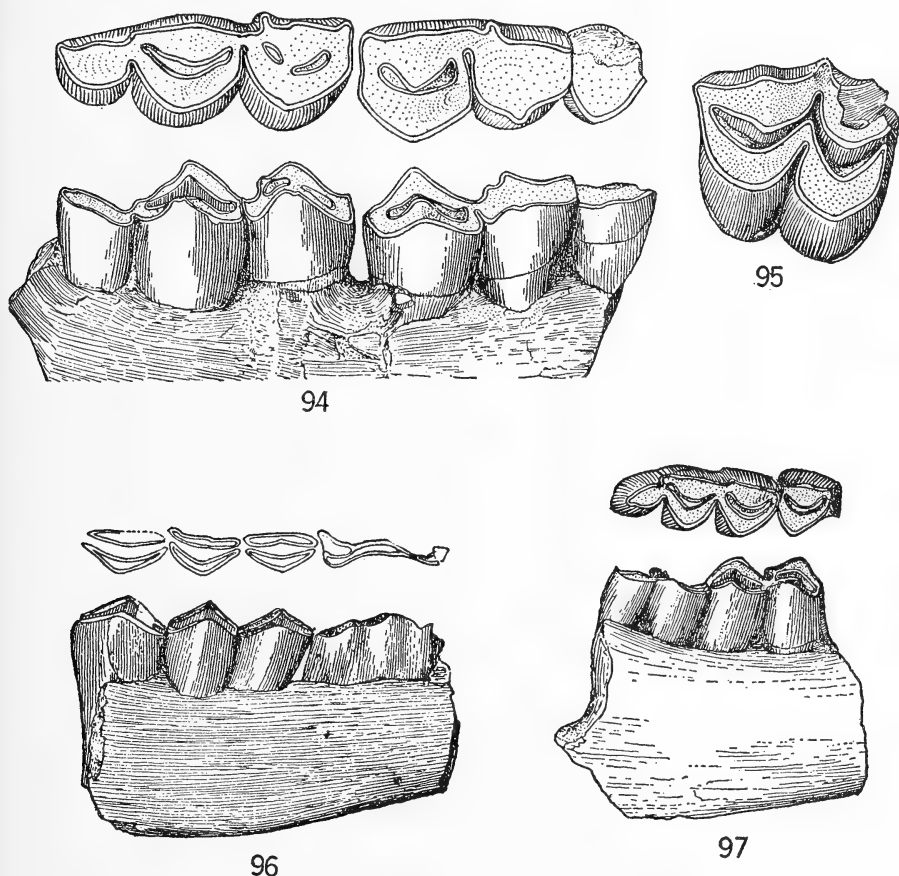
FIG. 94. *Procamelus?*, sp. Inferior dentition, no. 22482, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 95. *Procamelus?*, sp. Superior molar, no. 23129, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 96. *Procamelus?*, sp. Inferior milk teeth, no. 21554, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 97. *Procamelus*, sp. Fragment of mandible with M_2 and M_3, no. 21562, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

than 40 mm. in greatest diameter; others are much larger (compare figs. 100 and 101) ranging to a length between 80 and 90 mm.   It is possible that the smallest of these is merely a diminutive type of the next in size, but a considerable number of specimens seem not

to show an intergradation.   The largest of the Barstow forms are much smaller than the largest forms in the Ricardo fauna.   At least two of the Barstow types (compare figs. 98 and 99) evidently represent the genus *Procamelus*, as nearly as can be judged by the dentition and the metapodials referred to this group.   The largest forms of the Barstow fauna presumably represent the genera *Alticamelus* and *Pliauchenia* (compare figs. 100 and 101).   The broader specimens of the larger group are presumably *Pliauchenia*, the narrower ones *Alticamelus*.

A small astragalus with a portion of the dentition, no. 21554 (figs. 96 and 98), representing the smallest form known from the Barstow seems to represent *Procamelus*.   The astragalus is small and narrow.   The dentition represents the last two milk molars. The form is evidently a young individual of one of the two species smaller than *Alticamelus* and presumably to be referred to *Procamelus*.

The largest specimen representing the limbs is no. 21552 (fig. 92) and is a very large and slender anterior metapodial about 70 per cent longer than the anterior metapodial of a Recent camel.   This specimen presumably represents a form of *Alticamelus*.   The largest specimen representing the dentition in the Barstow fauna is a mandible (fig. 104), no. 21553, with two posterior molars, the roots of the premolars, and the canine.   On this specimen all of the four premolars have been present.   This mandible may belong also to *Alticamelus*.

In the posterior metapodials of the Barstow forms there are two distinct types of articulation at the proximal end.   One is shown in no. 21555 (fig. 107), in which the area for articulation with the cuboid and ectocuneiform is narrow transversely and the posterior hook is relatively large and high.   This type evidently represents *Procamelus*, and is to be associated with one of the two intermediate types of astragalus.   It corresponds very closely to the type seen in the proximal end of some of the Procamelus-like forms of the Miocene in the Great Plains region.   In the other form, no. 21556 (fig. 108), the proximal articular area is relatively much wider and the posterior hook is smaller.   This is possibly *Pliauchenia*.

In the form of the phalanges there is also a wide variation corresponding in general to the grade of difference in astragali.   The
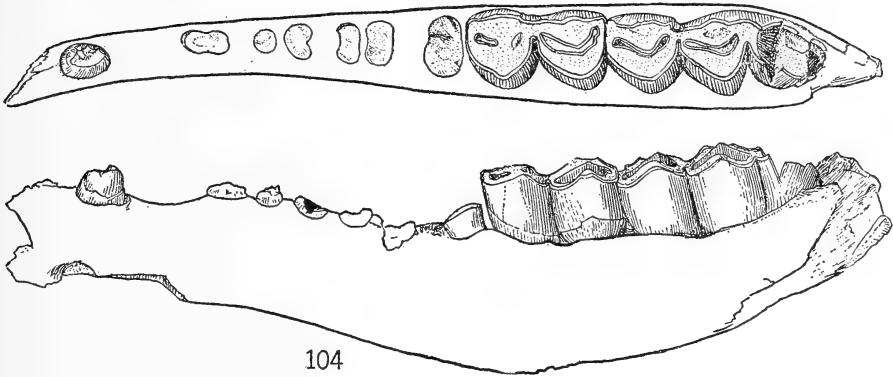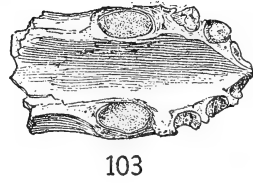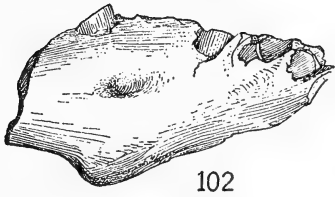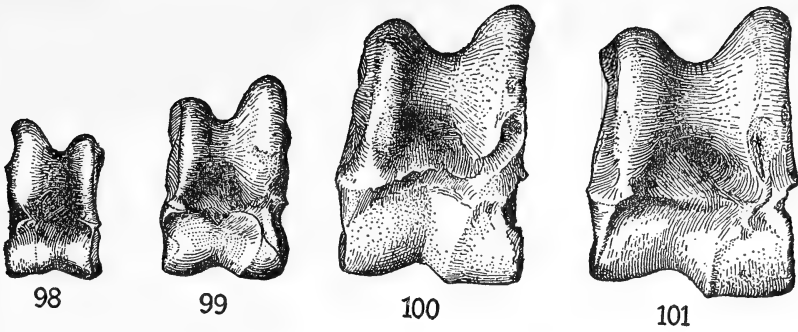
FIG. 98. *Procamelus*, sp. Astragalus, no. 21554, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 99. *Procamelus*, sp. Astragalus, no. 22481, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 100. *Alticamelus* or *Pliauchenia?*, sp. Astragalus, no. 23125, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 101. *Pliauchenia?*, sp. Astragalus, no. 21559, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 102. *Pliauchenia?*, sp. Anterior end of mandible, no. 22484, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 103. *Procamelus?*, sp. Anterior end of mandible, no. 22483, dorsal view, × ½. Barstow Miocene, Mohave Desert, California.

FIG. 104. *Alticamelus?*, sp. Mandible, no. 21553, × ½. Barstow Miocene, Mohave Desert, California.

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form represented by no. 21558 (fig. 109) may represent *Alticamelus*. Smaller forms seen in no. 21557 evidently belong to *Procamelus*.

A fine specimen, no. 21569, shows the greater portion of the anterior limb of an individual of approximately the same dimensions
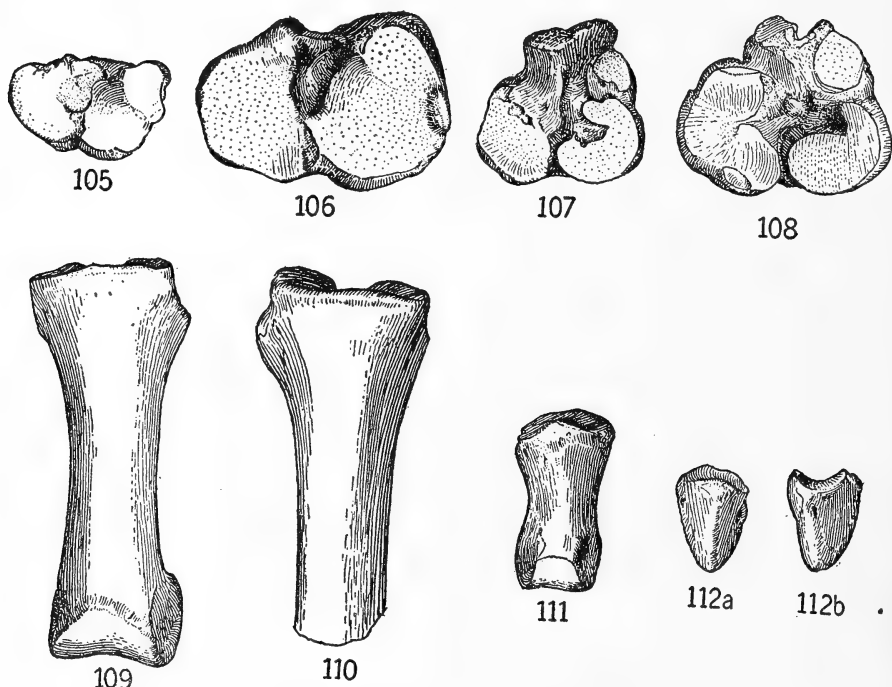
FIGS. 105 TO 112*b*.   Camel remains from Barstow Miocene, Mohave Desert, California.

FIG. 105, *Procamelus*, sp., proximal end of cannon bone, anterior limb, no. 22489, $\times \frac{1}{2}$; fig. 106, *Pliauchenia*, sp., proximal end of cannon bone, anterior limb, no. 22488, $\times \frac{1}{2}$; fig. 107, *Procamelus*, sp., proximal end of cannon bone, posterior limb, no. 21555, $\times \frac{1}{2}$; fig. 108, *Pliauchenia?*, sp., proximal end of cannon bone, posterior limb, no. 21556, $\times \frac{1}{2}$; fig. 109, *Alticamelus?* or *Pliauchenia*, sp., first phalanx, no. 21558, $\times \frac{1}{2}$; fig. 110, *Alticamelus?*, sp., first phalanx, no. 22487, $\times \frac{1}{2}$; fig. 111, *Procamelus* or *Pliauchenia*, sp., second phalanx, no. 22486, $\times \frac{1}{2}$; figs. 112*a* and 112*b*, *Procamelus?*, sp., ungual phalanx, no. 22485, $\times \frac{1}{2}$, fig. 112*a*, dorsal view, fig. 112*b*, side view.

as in *Alticamelus* or *Procamelus leptocolon* of the Pawnee Creek Miocene in the Great Plains region.

The upper dentition is not well shown in any of the Barstow specimens.   No. 23129 (fig. 95) represents a single upper molar and no. 21562 (fig. 97) a portion of a lower jaw.

BOVIDAE

Remains of *Merycodus* are among the most common fossils found in the Miocene of the Barstow syncline.   Fragments of horns or antlers are the most commonly recognized parts, and several hundred have been collected in the work on the Barstow fauna.

The forms commonly seen correspond most closely to *Merycodus necatus* described by Leidy from the Upper Miocene of the Great Plains region and figured by Cope from the Santa Fé region.   A second form, *Merycodus (?) coronatus* found in the Barstow repre-
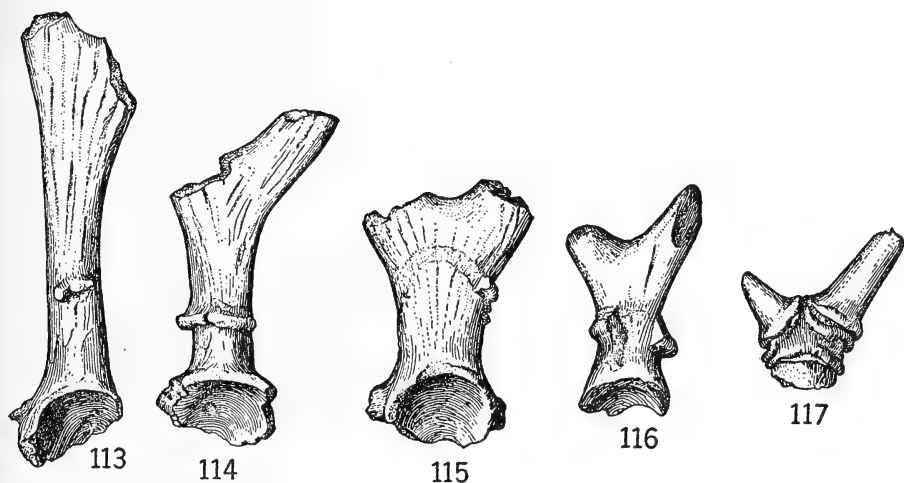
FIGS. 113 TO 117.   *Merycodus necatus?* Leidy.   Antlers, $\times \frac{1}{2}$.   A second species possibly represented.   Fig. 113, no. 22496; fig. 114, no. 22497; fig. 115, no. 22495; fig. 116, no. 22498; fig. 117, no. 21488.   Barstow Miocene, Mohave Desert, California.

sents a peculiar type which seems to the writer to be nearest to *Merycodus*.   It may represent a distinct genus or is possibly a sport.

MERYCODUS NECATUS? Leidy

This species is one of the common and characteristic forms of the Barstow fauna.   It is known by abundant antlers, a large portion of a skull, numerous parts of jaws with teeth, and many portions of the skeleton.

The antlers, as shown in figures 113 to 117, vary from large specimens with the tines dividing nearly evenly and relatively high above the base, to specimens in which the antler forks only a short

distance above the base. Though two types, the long antlers and the short antlers, can be recognized, they intergrade and evidently represent one species. The beam is commonly much flattened below the point of division. Only rarely in the highest antlers is the shaft nearly circular in cross-sections well above the base. In many cases the two tines are nearly equal. Usually there is a noticeable difference.

The burr is present in many specimens. It is commonly near the base of the horn. In some of the forms with the longest, most slender beam it may be more than an inch above the base. It is absent from many specimens. It may be situated immediately below the forks or may be far below them. In one specimen, no. 21488 (fig. 117), there is a burr on each tine above the division. In the specimen showing the skull the portion of a horn attached shows the burr about one-half an inch above the orbit.

In skull specimen no. 21551 (figs. 125a, 125b) the characters are near those of the fine specimen of *Merycodus osborni*, figured and described by Matthew.[33]

In the Barstow species the brain case seems narrower, the orbits a little less prominent, and the antlers are situated a little farther forward on the orbit than in *M. osborni*.

The frontoparietal suture in *M. osborni* is almost identical in position with a line connecting the posterior sides of the antler bases. In the Barstow species the suture bows far back of the antler bases.

The mandible of the Barstow form has approximately the dimensions of the forms figured by Cope[34] and referred to *M. necatus*, and the dimensions of the inferior cheek-tooth series are also similar. The maxillary is known only by small fragments.

The degree of hypsodonty of the molars is greater than in the Virgin Valley forms, so far as known, and much less than in the Pleistocene *Capromeryx*. M_3 has a strong hypoconulid lobe, which in some cases (no. 21490, fig. 130) approaches the size of the second or hypoconid-entoconid segment of the tooth. No suggestion of division of the posterior lobe of M_3 has been noted more than the presence of a faint concavity on the posteroexternal side of the third lobe (figs. 129, 130). The inferior premolars (figs. 128 and 131a) are moderately hypsodont. The posteroexternal fold is generally strongly marked almost to the base of the tooth.

[33] Matthew, W. D., Bull. Am. Mus. Nat. Hist., vol. 20, p. 106, 1904.
[34] Cope, E. D., U. S. Geog. Surv. West of 100th Meridian, vol. 4, p. 82, 1877.

The upper cheek-tooth dentition is represented only by scattered teeth (figs. 126, 127) which do not differ materially from those of the form from the Santa Fé beds referred to *M. necatus* by Cope.

In the milk dentition Dm_4 possesses a large anterior lobe at least equaling that of *Capromeryx* in relative size compared with the middle lobe.
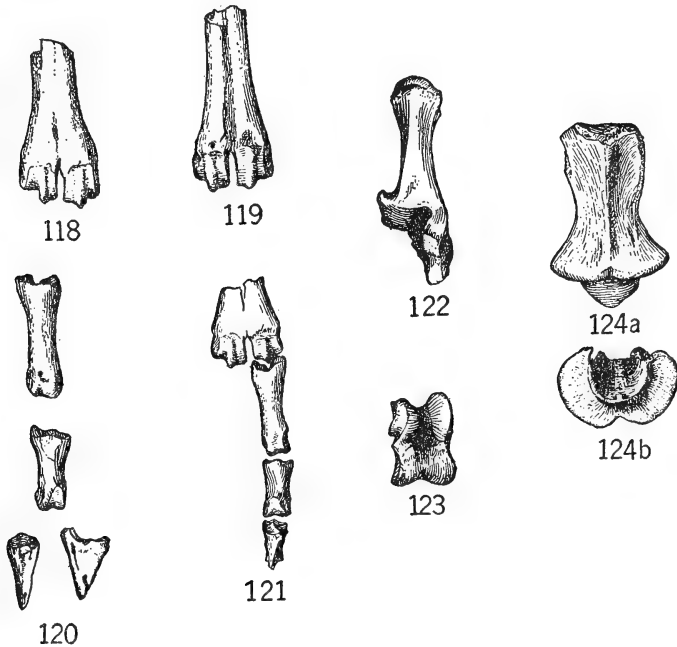
FIGS. 118 TO 120. *Merycodus*, sp. Metapodials and digit, no. 22502, $\times \frac{1}{2}$. Fig. 118, distal end of anterior cannon bone; fig. 119, distal end of posterior cannon bone; fig. 120, phalanges of digit. Barstow Miocene, Mohave Desert, California.

FIG. 121. *Merycodus*, sp. Distal end of anterior cannon bone and digit, no. 22499, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 122. *Merycodus*, sp. Calcaneum, no. 22501, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 123. *Merycodus*, sp. Astragalus, no. 22500, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIGS. 124a AND 124b. Bovid. Axis, no. 21499, $\times \frac{1}{2}$. Fig. 124a, ventral view; fig. 124b, anterior view. Barstow Miocene, Mohave Desert, California.

The limb elements are represented by numerous scattered bones of the manus and pes with portions of the larger bones.

The metapodials are not distinctly different from those of *Merycodus osborni* figured by Matthew.[35] The ungual phalanges are

[35] Matthew, W. D., Bull. Am. Mus. Nat. Hist., vol. 20, pp. 117, 120, 1904.
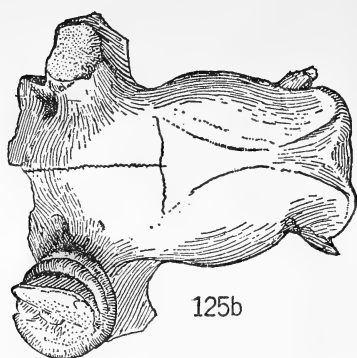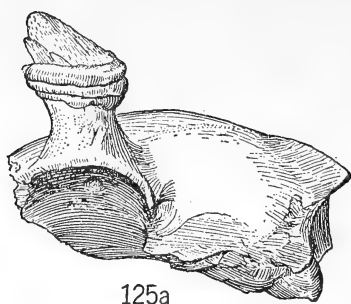
FIGS. 125a AND 125b. *Merycodus*, sp. Skull, no. 21551, $\times \frac{1}{2}$. Fig. 125a, lateral view; fig. 125b, dorsal view. Barstow Miocene, Mohave Desert, California.
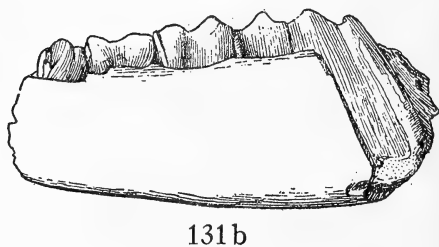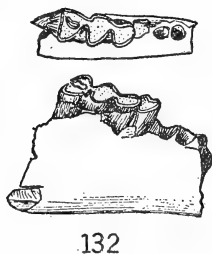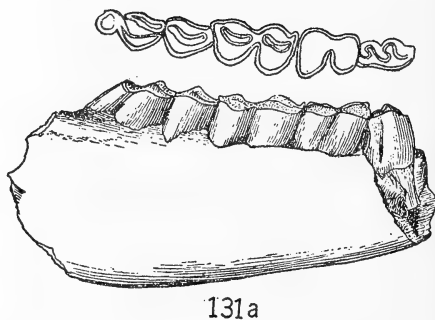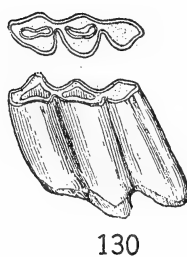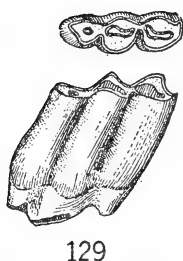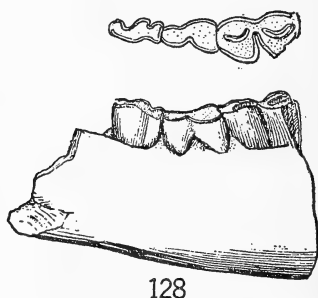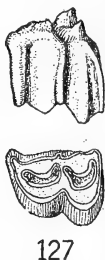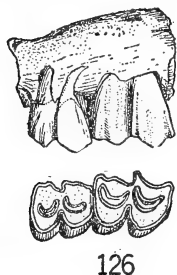
FIGS. 126 TO 132. *Merycodus necatus?* Leidy. Superior and inferior teeth, natural size. Fig. 126, M^1 and M^2, no. 22504; fig. 127, M^2, no. 22506; fig. 128, jaw fragment with P_3 to M_1, no. 22507; fig. 129, M_3, no. 22505; fig. 130, M_3, no. 21490; figs. 131a and 131b, fragment of mandible with inferior molars and P_4, outer and inner views of mandible and teeth, no. 22503; fig. 132, fragment of mandible with Dm_4, no. 21491. Barstow Miocene, Mohave Desert, California.

sharply pointed anteriorly, and do not show the Roman-nose form seen in the Pliocene antelopes of Thousand Creek and to some extent in *Capromeryx*.

An axis, no. 21499 (figs. 124*a*, 124*b*), from the Barstow is nearly identical in form and dimensions with the axis of *Capromeryx* from the Pleistocene of Rancho La Brea. The spout of the Barstow specimen is extended almost as far up on the sides as in *Capro-*

133   134
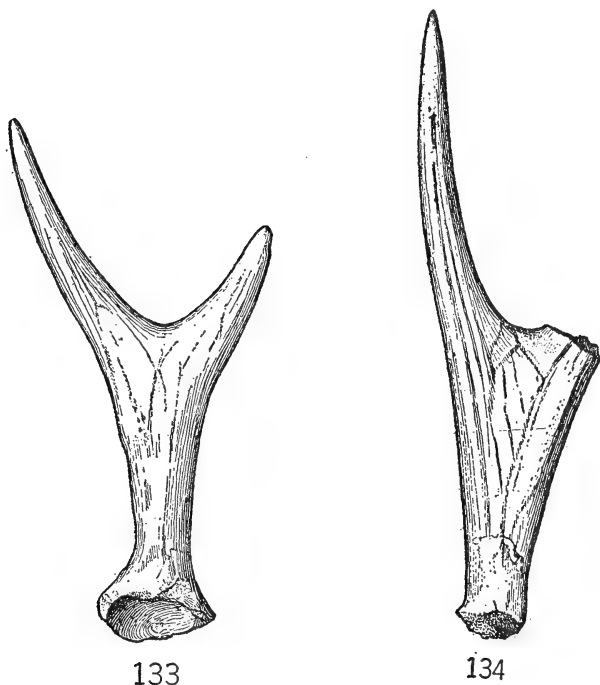
FIG. 133. *Merycodus necatus?* Leidy. Antler, no. 19832, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

FIG. 134. *Merycodus necatus?* Leidy. Antler, no. 22494, $\times \frac{1}{2}$. Barstow Miocene, Mohave Desert, California.

meryx, the Barstow form being in this respect possibly a trifle less advanced.

MERYCODUS? CORONATUS Merriam

M(?). coronatus Merriam. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, pp. 335–339, 1913.

The type specimen, consisting of a single fragmentary horn or antler, no. 20052, found by Buwalda and Mourning in 1913, repre-

sents a horn or antler of peculiar type, unlike any form known to the writer.

Specimen 20052 consists of a part of the beam, which divides into two nearly equal branches diverging almost horizontally. Upon the nearly even superior surface of the branches are a considerable number of small spikes or papillae. Of the two branches, one is projected approximately in the plane of the flattened beam. The other branch curves rather sharply away from this plane (fig. 135*b*). The branch bending away from the plane of the beam is the smaller. A number of the superior spikes or papillae bend out at a low angle from the convex side of the curve formed by the two branches. It seems probable that the plane of the beam was anteroposterior rather than transverse to the skull, and that the papillae on the convex side of the bow are on the outer or lateral, rather than on the inner side of the horn. If the smaller of these two horizontal branches is the anterior, this is the right horn.

The spikes or papillae on the upper side of the horn are in two rows. There are six on the concave side, and four on the convex side. The inner six are arranged in three pairs. Of the outer four there is a single large spike opposite the posterior inner pair and a similar one opposite the space between the anterior and middle inner pairs, and a pair of papillae arising from a common base opposite the middle inner pair. The inner papillae are nearly erect, excepting the most anterior one. The papillae on the outer side are directed outward at a low angle. Judging from the single specimen available, the anterior branches of the right and left horns of this animal curved in toward each other over the face, the other branches extended backward and slightly inward, making a crown-like or horseshoe-like structure above the head.

Specimen 20052 resembles most nearly the horn or antler of *Merycodus*, which it also approaches in size, and to some extent in the texture of the horn. It differs from *Merycodus* in the form of branching, and in the presence of the double row of superior spikes. The texture of the surface of specimen 20052 differs somewhat from that of any of the numerous *Merycodus* horns available from the Barstow Miocene. It is possible that the contrast is due in part to condition of weathering, but it seems partly due to difference in structure.
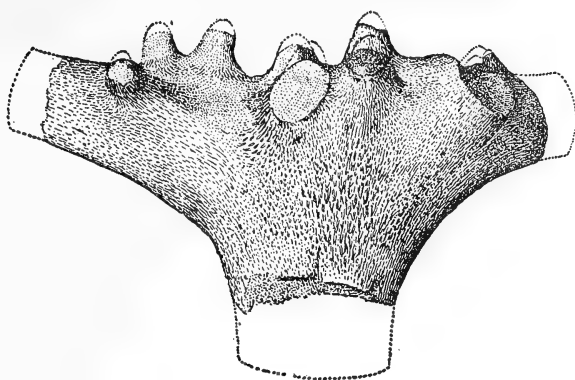
135a
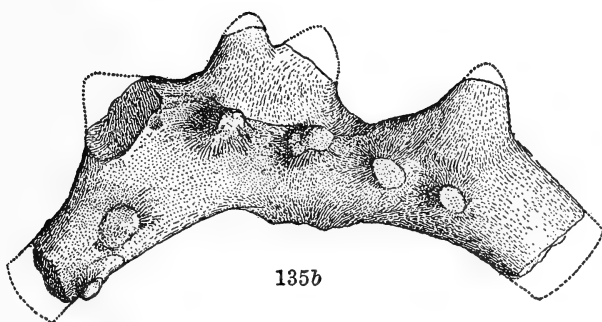
135b
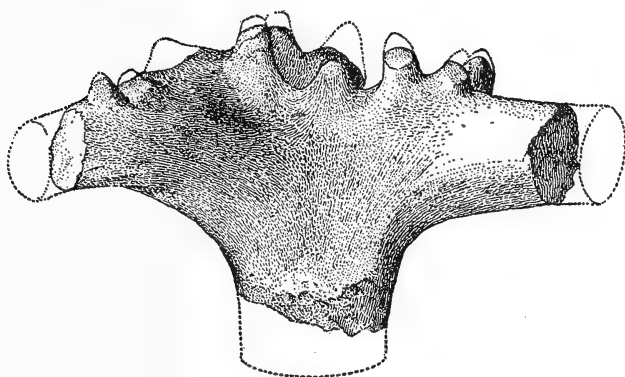
135c

FIGS. 135a TO 135c. *Merycodus? coronatus* Merriam.   Antler, no. 20052, natural size. Fig. 135a, outer side; fig. 135b, dorsal view; fig. 135c, medial side.   Barstow Miocene, Mohave Desert, California.

The peculiarities of specimen 20052 may be accounted for on the assumption that it is a "sport" or "monstrosity" of *Merycodus necatus*, a common form in the Mohave region. A large number of *Merycodus* horns have been found in the Barstow, but on no other specimen has there been noted any suggestion of the form seen in no. 20052, so that there was no common tendency to develop this type of horn.

For the present it is desirable to recognize this form as distinct from other species and probably nearest to *Merycodus*.
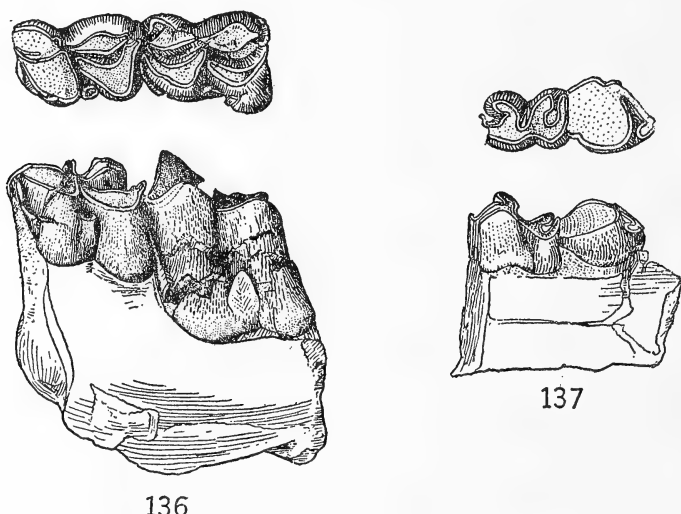
136

137

FIG. 136. *Dromomeryx* or *Cervus?*, n. sp. Dm4 and M1, no. 21218, natural size. Barstow Miocene, Mohave Desert, California.

FIG. 137. *Dromomeryx* or *Cervus?*, n. sp. Inferior teeth, no. 21219, natural size. Barstow Miocene, Mohave Desert, California.

CERVIDAE

DROMOMERYX or CERVUS?, n. sp.

Two jaw fragments with teeth from locality 2057, in the Barstow syncline, represent a form near *Dromomeryx*, but apparently more advanced than any described American form.

A fragmentary specimen, no. 21218 (fig. 136), shows Dm4 and M1. Both teeth resemble *Dromomeryx* in general form. They have the exceedingly rough enamel, the inner cusp between the protoconid and hypoconid pillars, and the shelf of the cingulum found in *Dromomeryx*. The dimensions of M1 are near those of specimens of *Dromomeryx* from the Snake Creek beds of Nebraska.

They differ from *Dromomeryx* in entire absence of the palaeomeryx fold, and in the greater length of M_1 than in the *Dromomeryx* specimens known to the writer.

This specimen may conceivably be a representative of the *Dromomeryx* group with relatively high crown and reduced palaeomeryx fold. Matthew and Cook[36] describe a somewhat similar form from the Snake Creek beds of Nebraska.

MEASUREMENTS OF No. 21218

Dm4, anteroposterior diameter along middle of crown............... 14.6 mm.
Dm4, transverse diameter across hypoconid......................... 12
M_1, anteroposterior diameter along middle of crown................ 18
M_1, transverse diameter across hypoconid......................... 14.1
M_1, height of crown on slightly worn protoconid pillar.............. 19

RICARDO FAUNA

Reptilia
  Testudinate remains
Carnivora
  Canid, small, near Canis? vafer Leidy
  Aelurodon? aphobus, n. sp.
  Aelurodon?, possibly aphobus, n. sp.
  Aelurodon?, n. sp. *a*
  Aelurodon?, n. sp. *b*
  Aelurodon or Tephrocyon, sp. *c*
  Aelurodon or Tephrocyon, sp. *d*
  Mustela? buwaldi, n. sp.
  Ischyrosmilus osborni, n. gen. and sp.
  Felid, large
  Felid, small, not Ischyrosmilus
Rodentia
  Lepus?, sp.
Proboscidea
  Tetrabelodon?, sp.

Equidae
  Hipparion mohavense Merriam
  Hipparion mohavense callodonte Merriam
  Hipparion, sp. *a*
  Hipparion, sp. *b*
  Pliohippus tantalus Merriam
  Pliohippus fairbanksi Merriam
  Pliohippus, sp. near mirabilis (Leidy)
Oreodontidae
  Merycochoerus? (Pronomotherium?) californicus, n. sp.
Camelidae
  Procamelus, sp. *a*
  Procamelus, sp. *b*
  Pliauchenia, sp.
  Alticamelus?, sp.
Bovidae
  Merycodus, near necatus Leidy

RELATION OF THE RICARDO FAUNA TO ITS ENVIRONMENT

The beds in which the Ricardo fauna occurs were evidently deposited on plains lying at the eastern base of a late Tertiary Sierra Range rising to a height of several thousand feet above the level of the Mohave area. The elevation of the region as a whole was probably not greater than at present and may have been somewhat less. The Ricardo deposits are probably in part land-laid, and in

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[36] Matthew, W. D., and Cook, H. J., Bull. Am. Mus. Nat. Hist., vol. 26, p. 409, 1909.

part water-laid. The volcanic materials which they contain may at times have accumulated rapidly, but seem in general to have been deposited so slowly that the region was nearly continuously habitable.

The Ricardo fauna consists largely of forms that would naturally prefer to inhabit plains areas, or might thrive in partly open, level regions at least as well as in other environment. *Hipparion*, *Pliohippus*, the camels, and *Merycodus* would find this a favorable habitat. The carnivores associated with them would not necessarily find the surroundings unfavorable provided sufficient cover were available. The mastodons and oreodonts might inhabit the plains or frequent the border of the mountain area to the west. There are no elements in the Ricardo fauna which are necessarily considered as representatives of a forest or mountain assemblage washed or carried out to the plains.

The Ricardo fauna suggests climatic conditions permitting the development of vegetation suitable for grazing animals. This indicates a somewhat heavier growth of grass than is found in this region at the present time. There is nothing in the constitution of the fauna to suggest conditions radically different from those obtaining in this region today, but the presumption is in favor of less extreme aridity than is now known on the western border of the Mohave Desert. The conditions prevailing in this region in Ricardo time were probably not widely different from those now obtaining in the southern portion of the Great Valley of California.

STAGE OF EVOLUTION AND RELATIONSHIPS OF THE RICARDO FAUNA

RELATION TO TERTIARY FAUNAS OF THE GREAT BASIN PROVINCE

The fauna of the Ricardo beds is widely different from that of the Middle Miocene Mascall and Virgin Valley, and is distinctly more progressive or later than that of the Upper Miocene Barstow. It is quite different from the Pliocene of Thousand Creek and is evidently less advanced. It differs also so far as known from the Rattlesnake Pliocene, and is presumably somewhat older.

Comparison of the Ricardo and Barstow faunas as shown in the following table shows almost complete specific separation of the two life assemblages, and considerable difference in the genera, especially in the Equidae, the best known group.

COMPARATIVE TABLE OF RICARDO AND BARSTOW FAUNAS

RICARDO FAUNA	BARSTOW FAUNA
Testudinata	Testudinata
Fragments, indet.	Testudo mohavense, n. sp.
	Aves
	Buteo, sp.
Carnivora	Carnivora
Canid, small, near Canis? vafer Leidy	Canid (Canis?), sp. small
Aelurodon? aphobus, n. sp.	Tephrocyon, near temerarius (Leidy)
Aelurodon?, possibly aphobus, n. sp.	Aelurodon, near wheelerianus Cope
Aelurodon?, n. sp. a	Aelurodon, Dinocyon, or Amphic-
Aelurodon?, n. sp. b	yon, sp.
Aelurodon or Tephrocyon, sp. c	Canid, indet.
Aelurodon or Tephrocyon, sp. d	Machaerodont, sp. a
Mustela? buwaldi, n. sp.	Machaerodont, sp. b
Ischyrosmilus osborni, n. gen. and sp.	Machaerodont, sp. c
Felid, large	Felid?, indet.
Felid, small, not Ischyrosmilus	Pseudaelurus, sp.
Rodentia	Rodentia
Lepus?, sp.	Lepus?, sp.
Proboscidea	Proboscidea
Tetrabelodon?, sp.	Tetrabelodon?, sp.
Equidae	Equidae
Hipparion mohavense Merriam	Hypohippus, near affinis (Leidy)
Hipparion mohavense callodonte	Parahippus? mourningi Merriam
Merriam	Merychippus (Protohippus) inter-
Hipparion, sp. a	montanus Merriam
Hipparion, sp. b	Merychippus calamarius stylo-
Pliohippus tantalus Merriam	dontus, n. var.
Pliohippus fairbanksi Merriam	Merychippus sumani Merriam
Pliohippus, sp. a near mirabilis (Leidy)	Protohippus? or Pliohippus?, sp.
	Suidae
	Prosthennops?, sp.
Oreodontidae	Oreodontidae
Merycochoerus? (Pronomotherium?)	Merycochoerus? buwaldi, n. sp.
californicus, n. sp.	
Camelidae	Camelidae
Procamelus, sp. a	Procamelus, sp. a
Procamelus, sp. b	Procamelus, sp. b
Pliauchenia, sp.	Pliauchenia, sp.
Alticamelus?, sp.	Alticamelus?, sp.
	Cervidae
	Dromomeryx or Cervus?, n. sp.
Bovidae	Bovidae
Merycodus, near necatus Leidy	Merycodus necatus ? Leidy
	Merycodus? coronatus Merriam

In nearly all cases in which it has been possible to make a satis-
factory comparison of forms representing similar groups in the two
faunas, the Ricardo types are seen to be more specialized. In the
Carnivora the common *Tephrocyon* of the Barstow seems to have
disappeared. Specimens showing some resemblance to *Tephrocyon*
are not clearly comparable to any Barstow species. The aeluro-
dons, which are the characteristic canids of the Ricardo fauna,
seem to be mainly, if not entirely, distinct and are generally more
specialized.

In the Equidae the abundant *Merychippus* fauna accompanied by
rare *Hypohippus*, *Parahippus*, and possibly *Protohippus* or *Plio-
hippus* of the Barstow is replaced in the Ricardo by a group con-
sisting of specialized *Hipparion* and *Pliohippus* species which may,
in part, be derived from the earlier Barstow types.

The only oreodont of the Ricardo is a Merycochoerus-like form
specifically distinct from that of the Barstow and more advanced.
The Ricardo camels include larger forms than those of the Barstow.
The known difference between the *Merycodus* forms is small, as
only fragmentary comparative material is available, but so far as
determinable the Ricardo species seems more specialized.

The general correspondence in groups but difference in species
between the Ricardo and Barstow leads one to consider as prob-
able the derivation of a considerable part of the Ricardo fauna
from stocks near those represented in the Barstow. If this is true
the difference in stage of evolution indicates that a considerable
time must have elapsed between the deposition of the beds in which
these faunas occur. The amount of difference shown in comparison
of these faunas does not represent less than one-third of the change
ordinarily taking place within the limits of a geological period. If
the Barstow is recognized as Upper Miocene, which seems unavoid-
able, it is difficult to consider placing the Ricardo lower than the
base of the Pliocene, or at the lowest, in the extreme upper limit of
the Miocene.

In comparison with the Cedar Mountain or Esmeralda fauna of
western Nevada the Ricardo shows much the same relationship as
to the Barstow. A few very fragmentary horse teeth from the
Cedar Mountain region suggest the presence of a type more ad-
vanced than those of the Barstow and nearer the Ricardo forms, but

the evidence is as yet unsatisfactory.   It is possible that in addition to the typical Cedar Mountain fauna a later faunal stage is present in the Cedar Mountain region.

Comparison of the Ricardo and Thousand Creek faunas is difficult because of absence of comparable material.   The known Carnivora of the Ricardo seem at least as progressive as those of Thousand Creek.   In the Equidae the Ricardo *Pliohippus* species seem near the stage of evolution of the forms from Thousand Creek. The Ricardo hipparions differ generally from what we know of the Thousand Creek representatives in less compression of the protocone of the upper cheek-teeth.   In this respect the Thousand Creek forms appear more progressive than those of Ricardo.

Merycodus, so well represented in the Miocene, is known in the Ricardo but not at Thousand Creek.   In the place of *Merycodus*, and possibly derived from it, we find in the Thousand Creek several advanced types of antelopes all unknown in the Ricardo.   The oreodont group represented in the Ricardo is not known to be represented at Thousand Creek.

As a whole, the Thousand Creek fauna seems more advanced than that of the Ricardo.   The difference may be due to geographic variation or to earlier appearance in the Thousand Creek region of immigrants reaching North America in Pliocene time.   It is probable that the difference between the Ricardo and Thousand Creek faunas is due in part to difference in stage of evolution, with the Ricardo as the earlier stage.   It is not probable that this difference amounts to more than a small portion of a geological period.

The relationship of the Ricardo and Rattlesnake faunas is presumably similar to that between Ricardo and Thousand Creek, as the Rattlesnake and Thousand Creek faunas seem in general closely related.   Such comparison as can be made suggests placing the Rattlesnake somewhat later than the Ricardo and near the position of the Thousand Creek.

Within the Great Basin province the relationships of the Ricardo fauna so far as known seem somewhat nearer to the Rattlesnake than to any other fauna.   The Ricardo represents a stage between the Upper Miocene Barstow and the Lower Pliocene Rattlesnake and Thousand Creek.

Comparison with Faunas of the Pacific Coast Province

In the sequence of late Tertiary faunas of the Pacific Coast province the Ricardo assemblage shows relationship to the faunas of the Chanac formation at the lower end of the San Joaquin Valley, the Lower Etchegoin or Jacalitos and the Middle Etchegoin of the North Coalinga region, and the Pinole Tuff-Orinda fauna of the San Francisco Bay region.

The Chanac fauna includes hipparions, *Merycodus*, a rhinocerotid, rare remains of *Protohippus*, and possibly *Pliohippus*. As yet no horses have been found in the Chanac which seem to correspond specifically to Ricardo forms, but the dominance of hipparions approaching in characters one of the Ricardo species suggests similar time stage of the two faunas. As rhinoceroses are unknown in the Ricardo the presence of a member of this group in the Chanac may mean considerable separation of these two faunas in time, or may indicate difference in habitat.

The presence of *Hipparion* in the lower Etchegoin and its failure to appear in the Middle Etchegoin may be taken to indicate closer approximation of the Ricardo to the lower division than to the middle or *Pliohippus coalingensis* zone. In the character of the *Pliohippus* species the *P. coalingensis* zone fauna is not widely removed from that of Ricardo, but there seems in general reason for considering the Middle Etchegoin as near the Rattlesnake-Thousand Creek stage of the Great Basin province, and it is not improbable that a fuller knowledge of the fauna may reveal types more advanced than those of the Ricardo.

The Pinole Tuff-Orinda fauna as known by the best representation from San Pablo Bay comprises an assemblage of forms suggesting the Thousand Creek, Rattlesnake, and Middle Etchegoin stages. It appears to be somewhat later than the Ricardo. In beds considered to represent a stage of the Orinda in the Contra Costa Hills *Hipparion* remains have been obtained representing a form specifically not distinguishable from *Hipparion mohavense* of Ricardo. Another assumed Orinda specimen, the type of *Hipparion platystyle*, closely approaches one of the large Ricardo *Hipparion* forms with somewhat compressed protocone. It is possible that the beds containing these Ricardo-like forms of the

Orinda are older than those on San Pablo Bay containing *Plio-hippus* species without associated *Hipparion*.

In general the Ricardo stage is not far from That of the Pinole Tuff-Orinda, but may be somewhat earlier.

COMPARISON OF THE RICARDO FAUNA WITH THAT OF THE AMERICAN TERTIARY OUTSIDE THE GREAT BASIN AND PACIFIC COAST PROVINCES

The faunas outside the Great Basin and Pacific Coast provinces of western North America with which the Ricardo is most closely comparable are the Snake Creek, Republican River, Alachua, and Blanco.

The Blanco Pliocene fauna of Texas resembles the Ricardo in the absence of horses of more primitive stage than *Protohippus*, and in the progressive stage of the carnivores and camels. The Blanco horses of the *Pliohippus* type appear more advanced than those of the Ricardo. Of the known Canidae *Borophagus* of the Blanco represents a very advanced stage, probably more progressive than any Ricardo form. No machaerodont cats are known in the Blanco, the only representative of the Felidae being a typical *Felis*. The only camels of the Blanco are referred to *Pliauchenia*, while the Ricardo forms seem to include *Procamelus*, *Pliauchenia*, and *Alticamelus*. The introduction of several edentates, including *Glypotherium* and *Megalonyx*, in the Blanco presumably indicates a later stage than the Ricardo, but the difference may be due to failure of southern edentate immigrants to reach California as early as they appeared in Texas.

The absence from the Blanco of typical aelurodons, machaerodonts, oreodonts, and merycodonts, taken with the presence of a variety of edentates and general advanced stage of the fauna, indicates that the Blanco is distinctly younger than the Ricardo. As the Blanco seems also younger than the Rattlesnake and Thousand Creek, which appear younger than the Ricardo, there is presumably a considerable gap between these two southern faunas of Pliocene age.

The Snake Creek fauna of western Nebraska contains many elements which correspond closely to those of the Ricardo. In the Carnivora two forms of *Aelurodon* are represented which are near

the stage of evolution of certain species in the Ricardo. With *Aelurodon* there are, however, at Snake Creek, several *Tephrocyon* species corresponding to types of the Great Basin Upper or Middle Miocene. The Snake Creek Equidae comprise *Protohippus*, *Pliohippus*, and *Neohipparion* of advanced types not less progressive than the Ricardo species. At Snake Creek there is also found abundant representation of the more primitive *Merychippus*, with *Parahippus* and *Hypohippus*. The remains of *Merychippus* make up over half of the collection of equid remains known from the Snake Creek. One of the common species of *Merychippus* is closely related to *M. calamarius* of the Santa Fé Upper Miocene.

The oreodonts of Snake Creek and Ricardo are not easily comparable, but may be near the same stage of evolution. The camels are also not widely different so far as can be determined. *Dromomeryx* present at Snake Creek is not more advanced than a Barstow form, as is also the *Merycodus* of Snake Creek. *Blastomeryx* is present at Snake Creek and unknown in both the Ricardo and Barstow. The bovid form, *Neotragocerus* at Snake Creek is not known at Ricardo, and approaches more nearly the stage of the Thousand Creek antelopes.

If it should appear that the Snake Creek represents more than a single faunal stage, one assemblage may be near the stage of the Ricardo or younger and one older.[37a]

The Republican River fauna of northwestern Kansas represents a stage recognized as near the beginning of the Pliocene. Matthew and Cook, who have made a most careful comparison of this assemblage with the Snake Creek, consider that modernization is more apparent in the latter.[37b] The Republican River canid fauna contains only advanced forms of the *Aelurodon* or *Dinocyon* type. The felid forms are presumed to be machaerodont. The Equidae include *Hypohippus*, *Protohippus*, and *Neohipparion*. Two oreodonts, *Merycochoerus* and *Merychyus*, are present, with camels of the genera *Procamelus* and *Pliauchenia*. *Dromomeryx* and *Blastomeryx* are not represented. Considering that the two areas discussed are widely separated geographically, it would seem

[37a] See Matthew, W. D., recently published review of Snake Creek fauna appearing while present article is in proof. Bull. Amer. Mus. Nat. Hist., vol. 38, pp. 183–185, 1918.

[37b] Matthew, W. D., and Cook, H. J., Bull. Amer. Mus. Nat. Hist., vol. 26, p. 368, 1909.

to the writer that the Republican River may not be far from the stage of faunal evolution shown by the Ricardo.

Relationship of the Ricardo to the Alachua of Florida is suggested especially by similarity of the *Hipparion* species. The American species most resembling the Ricardo hipparions include *H. plicatile* and *H. ingenuum* of the Archer beds, and *H. venustum* from Ashley River, South Carolina. This resemblance may be purely incidental, but possibly indicates a close genetic relationship, and approximately the same stage of early Pliocene for the beds in which these forms are found.

DESCRIPTION OF FAUNA

Testudinate Remains

Fragments of the shell of a large tortoise found in the Ricardo beds represent a form approximating the size of the large tortoises of the Barstow fauna. Several fragments of peripheral bones differ from those of *Testudo mohavense* of the Barstow in that the sulci between the dermal scutes are situated on prominent ridges, whereas in the Barstow form the sulci are sharply impressed and do not follow ridges.

Carnivora

The Carnivora of the Ricardo are in general quite distinct from those of the Barstow, and are also as a rule more progressive. The two faunas seem to have no forms in common, unless it be one of the canids and possibly one large cat. The genus *Tephrocyon* which forms an important part of the Barstow fauna is not certainly known in the Ricardo.

The Canidae are represented by a considerable variety of forms. These include a very small species like *Canis? vafer*; an Aelurodon-like form near *A. wheelerianus*, but with heavier carnassial; a second Aelurodon-like type near *A. wheelerianus*, but with different proportions of the mandible; a third very large Aelurodon-like form with massive molars; and species which may represent *Tephrocyon* or small aelurodons.

The cats include at least three types, one a machaerodont of the new generic group *Ischyrosmilus*; the other two forms are imperfectly known.

A new mustelid constitutes the only other known carnivore of this fauna.

CANID, small, near CANIS? VAFER Leidy

Specimen no. 22319 (figs. 138a, 138b) from locality 2731 in the lower portion of the Ricardo represents a small slender-jawed dog
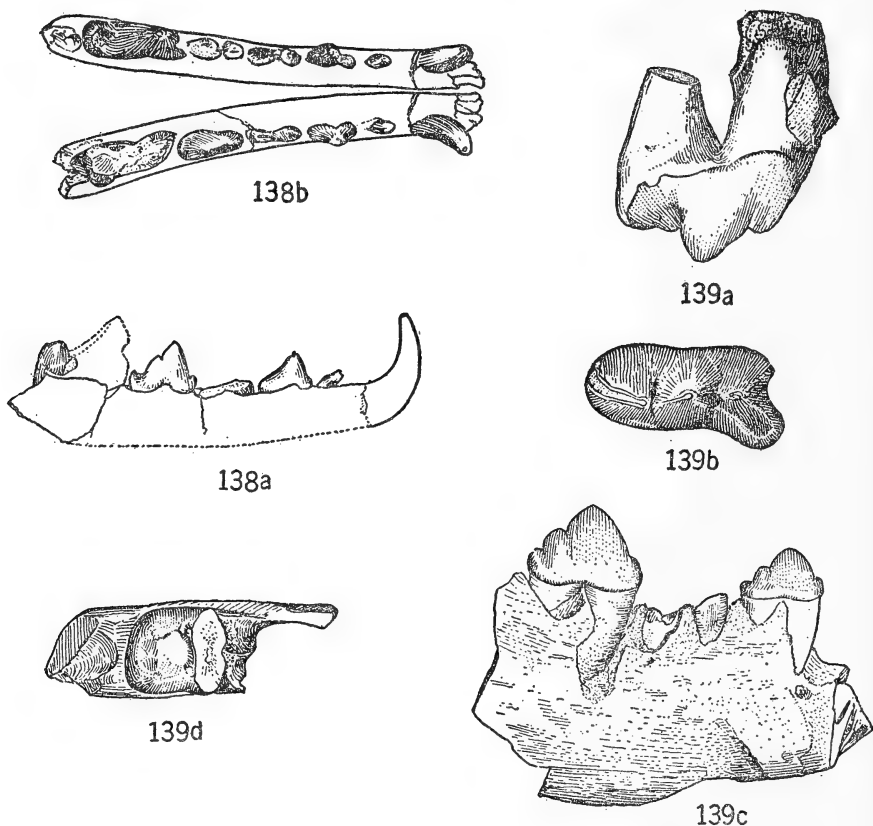
FIGS. 138a AND 138b. Canid, small, near *Canis? vafer* Leidy. Mandible, no. 22319, natural size. Fig. 138a, lateral view; fig. 138b, dorsal view. Ricardo Pliocene, Mohave Desert, California.

FIGS. 139a TO 139d. *Aelurodon* or *Tephrocyon*, sp. D. Upper and lower teeth, no. 22320, natural size. Fig. 139a, P^4, outer view; fig. 139b, P^4, occlusal view; fig. 139c, jaw fragment with P$_2$ and P$_4$; fig. 139d, heel of M$_1$. Ricardo Pliocene, Mohave Desert, California.

not unlike *Canis? vafer* Leidy of the Fort Niobrara formation, and represented by a similar type in the Snake Creek Pliocene of Nebraska.

The jaw is slender and the premolar teeth are fairly spaced. The lower canines are long and slender, the premolars are narrow. P$_2$

has a minute posterior basal tubercle. P_4 has a high, sharp principal cusp, with a prominent posterior cusp, a well developed basal tubercle or shelf, and a minute anterior basal tubercle.   Unfortunately the molars are all imperfect.   On M_1 the metaconid is well developed, the hypoconid is large and distinctly compressed laterally, the entoconid is relatively small but prominent.   A fragment of a jaw apparently representing this species contains a portion of M_2, and a small, two-tubercled M_3.

Until we can examine material with complete lower carnassial, and showing more fully the structure of the other molars, it does
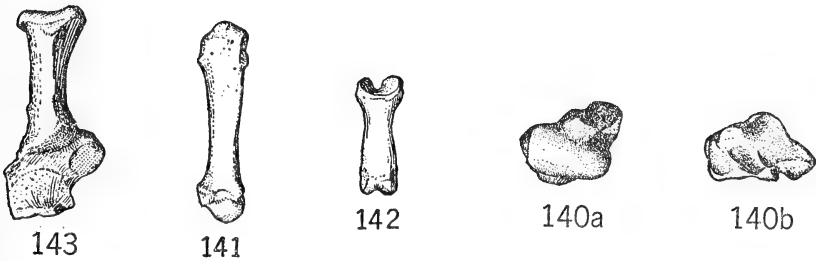
FIGS. 140a TO 143.   Canid?, indet.   Limb elements, no. 22321, $\times \frac{1}{2}$.   Fig. 140a, scaphoid, dorsal view; fig. 140b, scaphoid, ventral view; fig. 141, metacarpal 5; fig. 142, first phalanx; fig. 143, calcaneum.   Ricardo Pliocene, Mohave Desert, California.

not seem possible to make a close reference of this interesting little canid.

<div align="center">MEASUREMENTS OF No. 22319</div>

Length anterior side of canine to posterior side of M_1...............	47.8 mm.
P_1, anteroposterior diameter...................................	3.3
P_2, anteroposterior diameter...................................	6.2
P_4, anteroposterior diameter...................................	7.9
M_1, anteroposterior diameter...................................	a13
M_1, anteroposterior diameter of heel............................	4.6

a, approximate.

<div align="center">AELURODON? APHOBUS, n. sp.</div>

Type specimen, an upper jaw with P^4, M^1, M^2, and a portion of P^3, no. 21507, from locality 2281 in the upper portion of the Ricardo beds in the Western El Paso Range, California.

This specimen (figs. 144a, 144b) represents a very large canid with heavy crushing teeth.

M^1 is large with heavy protocone, and only moderately developed protoconule ridge. M^2 is a heavy tooth with large protocone ridge.

This tooth seems larger than in most specimens referred to *Aelurodon*.

P^4 is a heavy tooth with much reduced deuterocone. The proto-cone and tritocone are broken so that the form can not be clearly seen. When the type specimen was first examined by the writer, shallow external and internal grooves on the anterior region of the protocone seemed to show the separation of a well marked proto-

144a
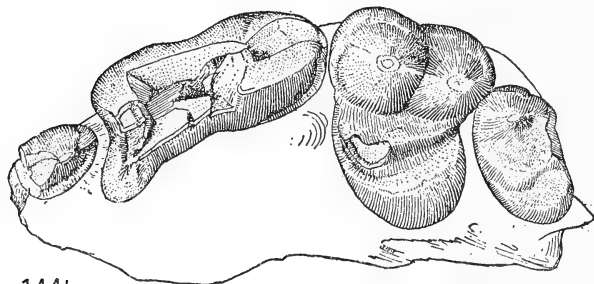
144b

Figs. 144*a* and 144*b*. *Aelurodon? aphobus*, n. sp. Upper jaw with P^4, M^1, and M^2, no. 21507, natural size. Fig. 144*a*, lateral view; fig. 144*b*, occlusal view of teeth. Ricardo Plio-cene, Mohave Desert, California.

style. In preparation of this tooth for study the region of the carnassial was damaged somewhat, and the grooves separating the protostyle region are no longer apparent. The construction of the anterior portion of the tooth is, however, much as in upper carnas-sials possessing an anterior style.

The portion of P^3 present shows that this was a heavy tooth.

The maxillary fragment shows no important characters. The infraorbital foramen is immediately over the anterior border of P^4.

MEASUREMENTS OF No. 21507

P³, transverse diameter of heel..................................	9	mm.
P⁴, anteroposterior diameter...................................	32.3	
P⁴, transverse diameter across protocone.......................	15	
M¹, anteroposterior diameter..................................	21.4	
M¹, transverse diameter..	28.7	
M², transverse diameter..	18.2	

This form shows some resemblance to *Dinocyon*, but M^2 is smaller and P^4 narrower. It differs from *Aelurodon wheelerianus* in the larger size, less prominent protostyle and deuterocone of P^4; larger inner lobe of M^1; and larger M^2. From *A. saevus* it differs in the much smaller deuterocone of P^4; longer and heavier protocone lobe of M^1; and larger M^2.

Canis? ursinus, described by Cope[38] from a lower jaw obtained from the Santa Fé marl, is a canid with large M_2 and M_3. The upper molars of the Ricardo specimen, no. 21507, are large and heavy and must have opposed a well developed crushing area on the heel of M_1 and on the tubercular lower molars. It may be that *C.? ursinus* and the Ricardo form are related or it is possible that, as Matthew[39] has suggested, *C. ursinus* is really an *Amphicyon*. It is improbable that the Ricardo form is an *Amphicyon*. Though M^2 is a large tooth the form of the maxillary posterior to M^2 makes the presence of a M^3 improbable.

AELURODON?, possibly APHOBUS, n. sp.

A large lower jaw, no. 22470 (fig. 145), represents an Aelurodon-like canid from locality 2769 in the upper portion of the Ricardo beds. This specimen includes the greater part of the mandible with P_4, M_1, and M_2, the teeth being badly worn and imperfect.

The lower jaw is short, heavy, and the inferior side below the posterior end of the molar series is markedly convex. The teeth are massive and thick transversely. The heel of M_1 is short and wide. M_2 is considerably longer anteroposteriorly than the heel of M_1.

The size and proportions of the dentition of specimen no. 22470 suggest those of *Aelurodon? aphobus* and it is not impossible that

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[38] Cope, E. D., U. S. Geol. Surv. West of 100th Meridian, vol. 4, p. 304, pl. 69, figs. 1 to 1b, 1877.

[39] Matthew, W. D., Bull. Am. Mus. Nat. Hist., vol. 16, p. 130, 1902.

this mandible represents an animal of the same type, possibly of the same species.

The Ricardo jaw resembles *Canis? ursinus* Cope to some extent in massiveness of jaw and dentition, but the mandible may differ in proportions and the tooth proportions are quite different. In *C.? ursinus* the masseteric fossa extends forward to a point below the posterior end of M_1, whereas in the Ricardo specimen this fossa does not reach farther forward than the posterior end of the alveolus of M_3. In the Ricardo mandible the last premolar and the carnassial are larger than in the type of *C.? ursinus*, whereas M_2 is smaller, and M_3 was presumably smaller judging from the alveolus.

The Ricardo form represented in no. 22470 was evidently a type with dentition specialized in a direction which gave relatively
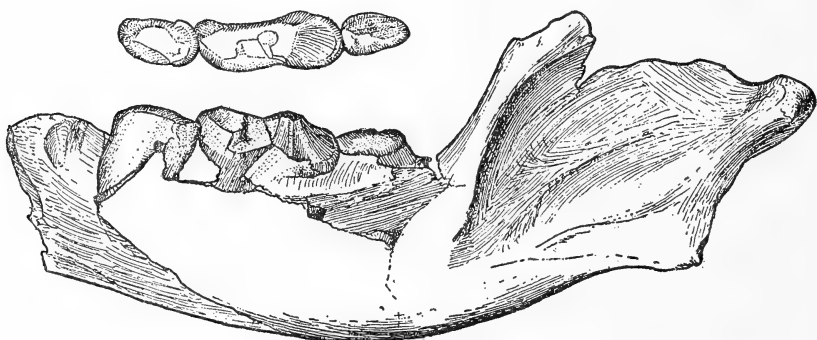
Fig. 145. *Aelurodon?*, possibly *aphobus*, n. sp. Mandible, no. 22470, × ½. Ricardo Pliocene, Mohave Desert, California.

more emphasis to function of P_4 and the carnassial, although the crushing area of the molar series was large; while in *C.? ursinus* the use of the crushing area of the tubercular molars was relatively more important.

In the importance of P_4 with M_1 in the lower cheek-tooth series, in the tendency to especial massiveness of P_4, and to some extent in the form of the posterior half of the mandible, the Ricardo jaw, no. 22470, suggests the late Pliocene *Hyaenognathus*. The Ricardo jaw is considerably longer than that of *Hyaenognathus*, but the most marked difference is found in the more specialized form of P_4 of *Hyaenognathus*. In the Ricardo specimen P_4 is apparently not radically different from a heavy *Canis* or *Aelurodon* tooth of this position. In *Hyaenognathus* P_4 is greatly broadened posteriorly,

and the principal cusp is extraordinarily enlarged. It is possible that *Hyaenognathus* is derived from the group to which the Ricardo species belonged. It may be noted that the upper dentition of *A.? aphobus*, to which it has been suggested that the Ricardo mandible, no. 22470, may be referred, is quite different from that of *Hyaenognathus* (*Porthocyon*) *dubius* with which the mandible of the type of *Hyaenognathus* has been compared.

COMPARATIVE MEASUREMENTS

	No. 22470	C?. ursinus type
Height of mandible below posterior end of M_1	44 mm.	45
Length of dentition from anterior side of P_4 to posterior side of M_2	73	a64.5
P_4, anteroposterior diameter	22.2	a17
M_1, anteroposterior diameter	36.5	31
M_1, anteroposterior diameter of heel	a9	....
M_1, greatest transverse diameter of heel	13.7	....
M_2, anteroposterior diameter	15.8	20

a, approximate.

AELURODON?, n. sp. A

A portion of a lower jaw, no. 21225 (figs. 146*a*, 146*b*), represents a heavy-jawed canid of a type similar to *Aelurodon wheelerianus* of the Barstow fauna but heavier, with much heavier and larger carnassial, and with smaller M_2. This form is quite certainly a new species of the *A. wheelerianus* type, but the writer prefers not to make this imperfect specimen the type.

M_1 of no. 21225 is very large, exceeding the Barstow specimens considerably in anteroposterior diameter. M_2 is represented by a small alveolus for the anterior root, and a very minute pit behind it which probably held the posterior root. There is no alveolus for M_3.

COMPARATIVE MEASUREMENTS

	No. 21225 Ricardo	A. wheelerianus? No. 19455 Barstow
Height of mandible below posterior end of M_1	32.7 mm.	a35.5
Thickness of mandible below posterior end of M_1	20.2	18
M_1, anteroposterior diameter	a35.7	28.4
M_2, anteroposterior diameter	a9.6	10.3

a, approximate.

AELURODON?, n. sp. B

A fragment of a lower jaw, no. 21317 (fig. 148), without teeth represents a canid species different from any of those reported from
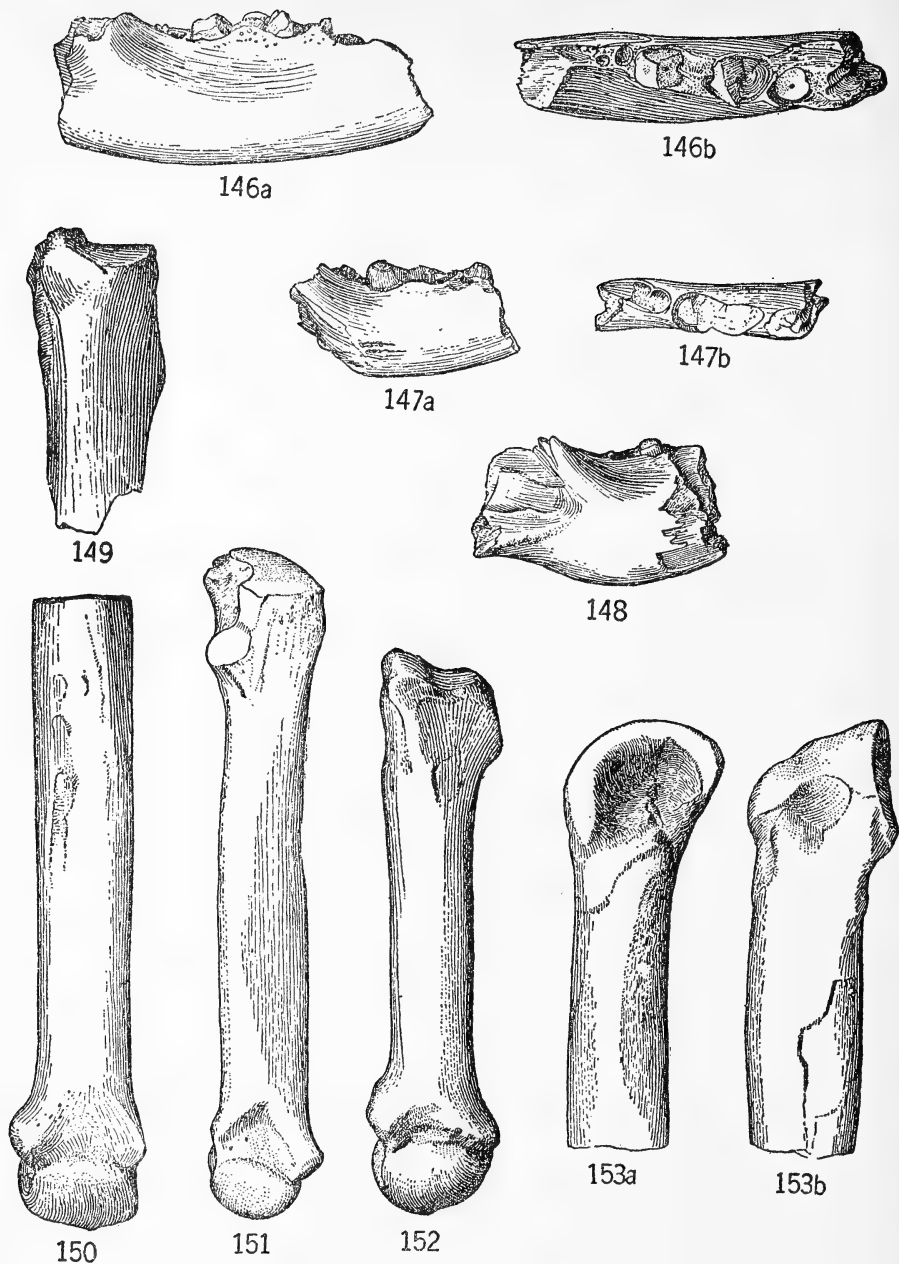
FIGURES 146a TO 153b represent forms from the Ricardo Pliocene, Mohave Desert, California.

FIGS. 146a AND 146b. *Aelurodon?*, n. sp. A, fragment of mandible, no. 21225, × ½, fig. 146a, lateral view, fig. 146b, dorsal view; figs. 147a and 147b, *Aelurodon* or *Tephrocyon*, sp. C, fragment of mandible, no. 21226, × ½, fig. 147a, lateral view, fig. 147b, dorsal view; fig. 148, *Aelurodon?*, n. sp. B, fragment of mandible, no. 21317, × ½; figs. 149 and 150, Canid, indet., metapodials, natural size, fig. 149, no. 22509, fig. 150, no. 21312; fig. 151, *Aelurodon?*, sp., metapodial, no. 21497, natural size; figs. 152 to 153b, *Aelurodon?*, sp., metapodials, natural size, fig. 152, no. 19809; figs. 153a and 153b, no. 19810.

1222

this fauna.   This form is smaller and with lighter mandible than *Aelurodon wheelerianus* of the Barstow, and larger than *Tephrocyon* near *temerarius* of that fauna.   It most nearly resembles *A. wheelerianus*, and is tentatively referred to *Aelurodon*.

<div align="center">COMPARATIVE MEASUREMENTS</div>

	No. 21317 Ricardo	No. 19455 Barstow
Height of mandible below protoconid of M_2................	29.6 mm.	a35.5
Thickness of mandible below protoconid of M_2............	12.7	18
Anteroposterior diameter of alveolus of M_2..............	12.8	10.3

a, approximate.

<div align="center">AELURODON or TEPHROCYON, sp. C</div>

A portion of a lower jaw, no. 21226 (figs. 147*a*, 147*b*), represents a canid form much smaller than the three types referred tentatively to *Aelurodon*, and certainly specifically different.   The mandible is heavy and thick, and the fragment of the carnassial present seems to have a heavy crushing heel.   The form is probably an *Aelurodon* or *Tephrocyon* as yet undescribed.

<div align="center">MEASUREMENTS OF No. 21226</div>

Height of mandible below heel of M_1.............................	23.7 mm.
Thickness of mandible below heel of M_1..........................	11.9
M_1, anteroposterior diameter....................................	a23.5
M_1, transverse diameter of heel................................	9.1

a, approximate.

<div align="center">AELURODON or TEPHROCYON, sp. D</div>

An interesting specimen, no. 22320, from locality 2733, in the lower portion of the Ricardo formation includes fragments of the skull with a portion of the dentition including the upper carnassial, P_2, P_4, and the heel of M_1.   The upper carnassial is of the typical *Aelurodon* type with large, sharply separated protostyle.   It represents a form smaller than the better known *Aelurodon* forms, the animal having approximately the dimensions of the average specimens of *Tephrocyon*.   The lower premolars (fig. 139*c*) are heavy, thick transversely, and with well developed cingulum. P_2 has a prominent posterior cusp with small but well marked anterior and posterior basal tubercles. P_4 has a prominent posterior cusp with well marked anterior and posterior basal tubercles.   The heel of

M_1 (fig. 139d) shows the hypoconid and entoconid of approximately the same size. Both tubercles are low, and the heel has distinctly a crushing function.

This specimen may represent a type of animal known in other material from this region and referred to *Aelurodon* in the descriptions above.

LIMB ELEMENTS

A number of limb elements representing canid forms from the Ricardo beds are presumably to be referred to some of the species described above from jaws and teeth.

Two very large specimens, nos. 21312 and 22509 (figs. 149, 150), possibly represent *Aelurodon? aphobus*. A smaller specimen, no. 21497 (fig. 151), is possibly the undescribed form *Aelurodon*, n. sp. A.

The distal end of a femur, no. 21314, may represent an *Aelurodon* or *Tephrocyon* species.

In specimen no. 22321 (figs. 140a to 143), found associated with parts of a skull and dentition, no. 22320, at locality 2733, there is represented a considerable portion of a foot with short, rather heavy, strongly curved, cat-like metacarpals. In this specimen the proximal end of metacarpal III shows characters not unlike those of specimen no. 22289 from the Cedar Mountain Miocene of Nevada. Only a proximal end is preserved. The facet for articulation with the magnum is not as deeply curved as in the puma, but the median proximal facet for articulation with metacarpal II is raised relatively high, and has nearly the same position as this facet in the puma. This facet is, however, not as large as in the puma and is not as well developed on the posterior side. Behind the excavation below the median facet for articulation with metacarpal II there is a small round facet also for contact with metacarpal II. The writer has not seen this facet in the Canidae. It is not present in the puma, the sabre-tooth, or in *Felis atrox*. On the external side the lower excavated face for contact with metacarpal IV is not as deeply cut as in the cats, but is deeper than in *Aenocyon dirus*. The upper portion of the facet for contact with metacarpal IV is broken anteriorly. Unfortunately the writer has not had good material of *Aelurodon* immediately available for comparison.

MUSTELA? BUWALDI, n. sp.

Type specimen a lower jaw with P_1 to M_1, no. 21323, from locality 2282, Ricardo beds, Mohave Desert, California.

A lower jaw with the carnassial and all of the premolars from the Ricardo beds (fig. 154) represents a mustelid not known elsewhere in the Tertiary of the Great Basin province.

P_1 to P_3 are simple cones without accessory tubercles. P_4 has a posterior cusp.

M_1 has a low mustelid or musteline type of crown. The protoconid and paraconid are nearly equal. The metaconid is prominent and sharply separated from the protoconid. The heel is long and basin-shaped. The hypoconid is fairly prominent. A long, curved posterointernal ridge connects posteriorly with the hypoconid and internally with the base of the metaconid. The external cingulum of M_1 is faintly marked on the heel, but is not visible on the outer side of the protoconid, although the teeth are but little worn.

MEASUREMENTS OF No. 21323

Length, anterior side P_1 to posterior side M_1	26.9 mm.
P_1, anteroposterior diameter	2.4
P_2, anteroposterior diameter	4.5
P_3, anteroposterior diameter	5
P_4, anteroposterior diameter	6.1
M_1, anteroposterior diameter	9.9
M_1, length of heel on outer side	3
M_1, width of heel	3.9

ISCHYROSMILUS Merriam

ἰσχυρός, strong; σμίλη, knife

Machaerodus? J. C. Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 4, p. 171, 1905.

Ischyrosmilus Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 10, p. 524, 1918.

Type species *Machaerodus? ischyrus* Merriam from beds near McKittrick on the western border of the San Joaquin Valley, California. The type is known only by the mandible and inferior dentition.

Mandible massive; flange clearly marked, relatively wide anteroposteriorly, slightly deeper than in *Smilodon*, not as strongly developed as in typical *Machaerodus*; length of diastema much as in *Machaerodus*, but shorter than in *Smilodon*. P_3 very small, and with one root. P_4 with a single posterior cusp or with incipient

division of this cusp. M_1 without metaconid and heel. The group is known only from beds referred to the Pliocene.

Ischyrosmilus differs from the *Dinictis* group in the absence of M_2, absence of heel and metaconid of M_1, great reduction of P_3, and in the relatively large size of the flange below the diastema. From *Hoplophoneus* it differs in the absence of heel and metaconid of M_1, and in the somewhat greater anteroposterior diameter of the relatively shallow flange. From typical *Machaerodus* it differs in the greater reduction of P_3, and in the greater anteroposterior diameter of the relatively shallow flange. From *Smilodon* it differs in the shorter diastema, larger flange, and more simple form of the posterior lobe of P_4. This group is nearest *Machaerodus*, and may be considered as a subgenus under that division. The fact that
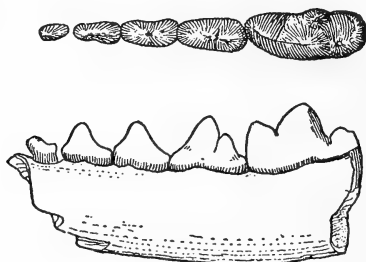
FIG. 154.   *Mustela?, buwaldi*, n. sp.   Mandible with P_1 to M_1, no. 21323, $\times$ $1\frac{1}{2}$.   Ricardo Pliocene, Mohave Desert, California.

two forms are found which resemble each other in the general characters through which they differ from other groups, though they are evidently different specifically, seems to require recognition in the classification; particularly is this desirable when the species thus distinguished are in a geographic province from which other *Machaerodus* species of similar age are not known.

This genus approaches the Pleistocene *Smilodon* more closely than does any American Tertiary machaerodont thus far described. The characters of the lower dentition differ from those of *Smilodon* only in the less advanced development of the second posterior cusp of P_4. The presence of a small P_3 in *Ischyrosmilus* is not a distinguishing character, as this tooth may be present and fully as large in *Smilodon californicus*. The mandibles of the two genera are distinguished by the greater elongation of the diastema region and

the slightly smaller flange in *Smilodon*.   This difference is presumed to represent correlation with the large upper canine in *Smilodon*.

Although *Smilodon* is presumed to be derived from *Machaerodus*, as yet the former has been found only in the New World and the latter in the Old World, and no described form of *Machaerodus* furnishes the characters required in the ancestor of *Smilodon*.   As *Smilodon* is an American genus, and the sabre-tooth is characteristic of America rather than of the Old World, this genus might be presumed to be derived from an American Pliocene form.   Of the known American forms *Ischyrosmilus* most nearly approaches *Smilodon*, and the similarity of the two genera is closer than is the
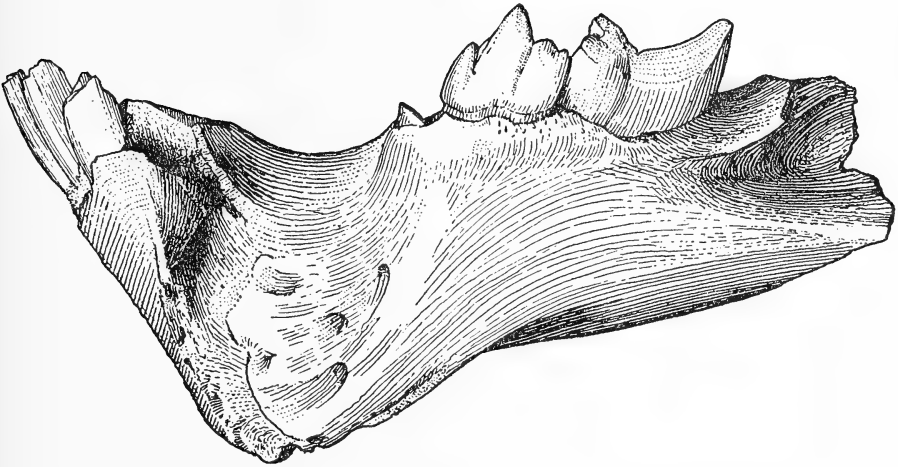
Fig. 155. *Ischyrosmilus osborni*, n. sp.   Type specimen, mandible with dentition, no. 19476, $\times \frac{9}{10}$.   Ricardo Pliocene, Mohave Desert, California.

resemblance of any Old World representative of the genus *Machaerodus* to *Smilodon*.   This does not mean that *Smilodon* is derived immediately from *Ischyrosmilus*.   The gap between the two is wide, and it is not improbable that *Ischyrosmilus* represents only one specialized branch of a large division leading toward *Smilodon*.

ISCHYROSMILUS OSBORNI, n. sp.

Type specimen, a portion of a left lower jaw with dentition, no. 19476, Univ. Calif. Col. Vert. Palae.   From the Ricardo beds near Red Rock Cañon, California.

The type specimen (fig. 155) represents a species most nearly related to *Ischyrosmilus ischyrus* from McKittrick, on the western

side of the San Joaquin Valley, California. The specimen of
I. osborni represents the same portion of the mandible shown in
the type of *I. ischyrus,* so that a close comparison can be made.
This species differs from *I. ischyrus* in its smaller size, somewhat
flatter anterior face of the symphysial region, much thinner or
transversely narrower cheek-teeth, and in the division of the pos-
terior lobe of P$_4$ into two cusps.

The anterior end of the masseteric fossa in the specimen of
I. osborni is much narrower vertically than in the type of *I. ischy-
rus,* and suggests that the form of the jaw in this region may be
found to be different in the two species.

The incisors have lost the greater part of their crowns, but seem
smaller and narrower transversely than in *I. ischyrus.* The canine
is not represented.

P$_3$ is known only by the root with a small portion of the crown.
The root is small and round in cross-section, with no suggestion of
division.

P$_4$ resembles the corresponding tooth of *I. ischyrus,* excepting in
the slightly larger size of the posterior lobe, and in its beginning
division into two cusps.

COMPARATIVE MEASUREMENTS

	I. ischyrus No. 8140 Tulare?	I. osborni No. 19476 Ricardo
Length from anterior side of I$_1$ to posterior side of M$_1$.....	123 mm.	101
Length from anterior side of canine to posterior side of M$_1$....	107	81
Width of anterior face of symphysial region.............	52	a36
Depth of jaw across the middle of the flange.............	58	44
Depth of mandible below posterior end of P$_4$.............	37.5	32.3
Length of inferior diastema...........................	33.5	26.5
Width of I$_1$ transversely................................	4	2.5
Wdith of I$_2$ transversely................................	6.5	4
Anteroposterior diameter of inferior canine.............	14.5	a10
Anteroposterior diameter of P$_3$........................	7.2	a6.4
Anteroposterior diameter of alveolus of P$_3$.............	8.1	7
Anteroposterior diameter of P$_4$........................	20	16.7
Anteroposterior diameter of M$_1$........................	28.5	24
Transverse diameter of M$_1$............................	15	11

a, approximate.

M$_1$ is relatively large compared with P$_4$. This tooth and P$_4$ are
both much thinner transversely than in the other species. There
is no suggestion of a posterior heel or of a metaconid. A peculiar
character exists in the extension of the concave face between the

bases of the protoconid and paraconid on the inner side of M_1 downward to the cinculum. There is no alveolus for M_2, and as the specimen represents a relatively young animal without heel or metaconid on M_1 it is to be presumed that the second lower molar was not normally present.

As in the case of *Ischyrosmilus ischyrus*, the Ricardo species shows resemblance to *Machaerodus palaeindicus* of the Indian Siwaliks in form of the mandible, shape of the flange, and length of the diastema. The Ricardo specimen and the type of *I. ischyrus* differ from the Siwalik form in the much reduced P_3. In *Machaerodus palaeindicus* according to Lydekker P_4 possesses but a single posterior cusp as in *I. ischyrus*. In the Ricardo form the posterior cusp is divided by a sharp groove on the inner side, but the size of the two cusps combined in the posterior lobe of this tooth in the Ricardo specimen is scarcely greater than that of the single posterior lobe in the type of *I. ischyrus*.
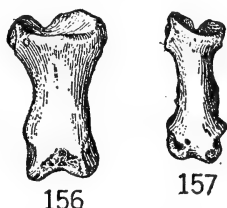
FIGS. 156 AND 157. Felid, indet. Phalanges, $\times \frac{1}{2}$. Fig. 156, no. 21222; fig. 157, no. 21313. Ricardo Pliocene, Mohave Desert, California.

FELID LIMB ELEMENTS

Two phalanges, nos. 21222 and 21313 (figs. 156, 157), presumably represent different species. The former represents a large cat probably a machaerodont. No. 21313 is much more slender and may belong to a feline form.

MEASUREMENTS OF PHALANGES

	No. 21222	No. 21313
Greatest length	37.5 mm.	36.5
Greatest width at proximal end	22.5	15
Least transverse diameter	13.5	9.1

FELID?, indet.

A fragment, no. 21696, representing the posterior end of a mandible from Ricardo is from a large form of the type represented in

the Barstow fauna by a similar fragment, no. 21571. The Ricardo specimen is almost identical in its character with the form known from the Barstow fauna, but is slightly larger. The position of the angle indicates a character of the feline rather than a machaerodine group if this form is a felid. The angle is farther removed from the condyle than in the more specialized machaerodine forms. It is also almost immediately below the posterior side of the base of the coronoid process, whereas in the specialized machaerodine forms the angle is situated below the outer end of the condyle.

RODENTIA

A small astragalus, no. 21496, like that of a jackrabbit, from locality 1805 in the Ricardo, represents a rodent type near *Lepus*

158a   159   158b
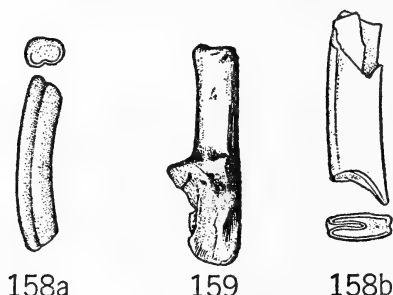
FIGS. 158a TO 159. *Lepus?* or *Hypolagus?*, sp. Fig. 158a, incisor, no. 22337, × 2. Fig. 158b, upper tooth, no. 22338, × 2; fig. 159, calcaneum, no. 22336, natural size. Ricardo Pliocene, Mohave Desert, California.

or *Hypolagus*. Other material, possibly of this form, is shown in figures 158a to 159.

PROBOSCIDEA

TETRABELODON?, sp.

A number of fragments of a large mastodontine form were obtained in the Ricardo beds.

A considerable portion of a lower jaw, no. 22681 (fig. 160), shows the character of the lower molar teeth, and a portion of the symphysial region. The symphysis is elongated and the cross-section of the lower tusk indicates that it was of considerable size. The pattern of the lower cheek-teeth is that of an early Pliocene or late Miocene type with comparatively simple outlines of the tubercles or transverse ridges, but with secondary tubercles in the space

between the transverse ridges. A piece of an upper tusk shows a portion of an enamel covering. A small lower incisor (no. 21318, fig. 162) has a portion of the enamel band still intact.
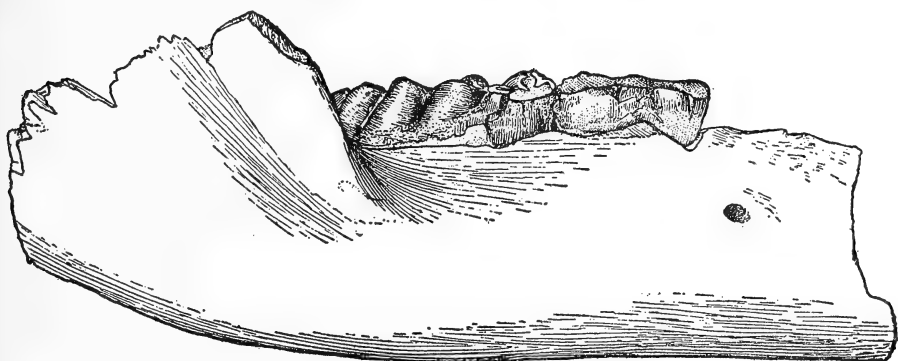
FIG. 160. *Tetrabelodon?*, sp. Mandible, no. 22681, lateral view, $\times$ .225. Ricardo Pliocene, Mohave Desert, California.

161

162
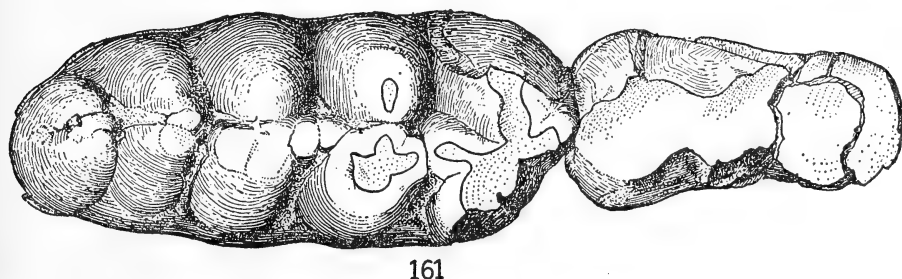
FIGS. 161 AND 162. *Tetrabelodon?*, sp. Lower cheek-teeth and incisor, $\times$ .475. Fig. 161, no. 22681; fig. 162, no. 21318. Ricardo Pliocene, Mohave Desert, California.

EQUIDAE

The horse group is known in the Ricardo fauna by several clearly marked species representing the genera *Hipparion* and *Pliohippus*. The Ricardo horses are as a group much more advanced than the Barstow species. A single Pliohippus-like specimen from Ricardo is to be considered as possibly not more progressive than a relatively very rare form from the Barstow, otherwise all of the Ricardo forms seem more advanced than those of the Barstow.

The *Pliohippus* species of the Ricardo resemble in structure a number of early Pliocene or late Miocene forms appearing in various faunas of western North America. The *Hipparion* forms of Ricardo show at least as close a resemblance to the species of Asia and Europe as to any in the known American faunas.

HIPPARION MOHAVENSE Merriam

FIGURES 163 TO 170*b*

Hipparion? mohavense Merriam. Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 436, figs. 1*a* to 3*b*, 1913.

Type specimen an upper premolar three, no. 19787 (fig. 167), associated with M^1 and M^2, from the Ricardo beds, in the El Paso Range, northwestern border of the Mohave Desert, California.

Upper cheek-tooth crowns nearly straight, length a little more than twice the transverse diameter in unworn specimens. Protocone small, subcircular or slightly compressed laterally in the type material, separate from protoconule almost to the base of the crown. Enamel bordering the fossettes with numerous plications which commonly show rounded rather than angular terminations. Middle region of outer side of paracone and metacone commonly flat. Mesostyle narrowing very gradually beyond the base. Cement covering well developed.

Lower cheek-teeth with metaconid-metastylid column long anteroposteriorly, narrow transversely, and showing a wide longitudinal inner furrow. The small fold commonly seen on the anteroexternal angle of the lower cheek-teeth of *Hipparion* forms is present in several specimens. The enamel of the lower cheek-teeth shows a tendency to form secondary plications especially on the inner side of the parastylid ridge. The greatest transverse diameter of the lower cheek-tooth series is seen in P_4, and commonly at the posterior end of that tooth. The crowns are all heavily cemented.

Since the description of the type specimen the amount of material representing *Hipparion mohavense* has been much increased through the efforts of the parties working under J. P. Buwalda in December 1913 to May 1915, and by several other parties. One fine specimen discovered by Chester Stock includes the complete upper cheek-tooth dentition (no. 21320, figs. 163, 164). This specimen is evidently specifically identical with the typical form. The dimensions are nearly the same as those of the type, the crowns of no. 21320 being relatively narrow due to less advanced wear. The plications of the enamel in no. 21320 are less marked than in the type, though the latter specimen is from an older individual. There is also seen in specimen no. 21320 a tendency to the forma-
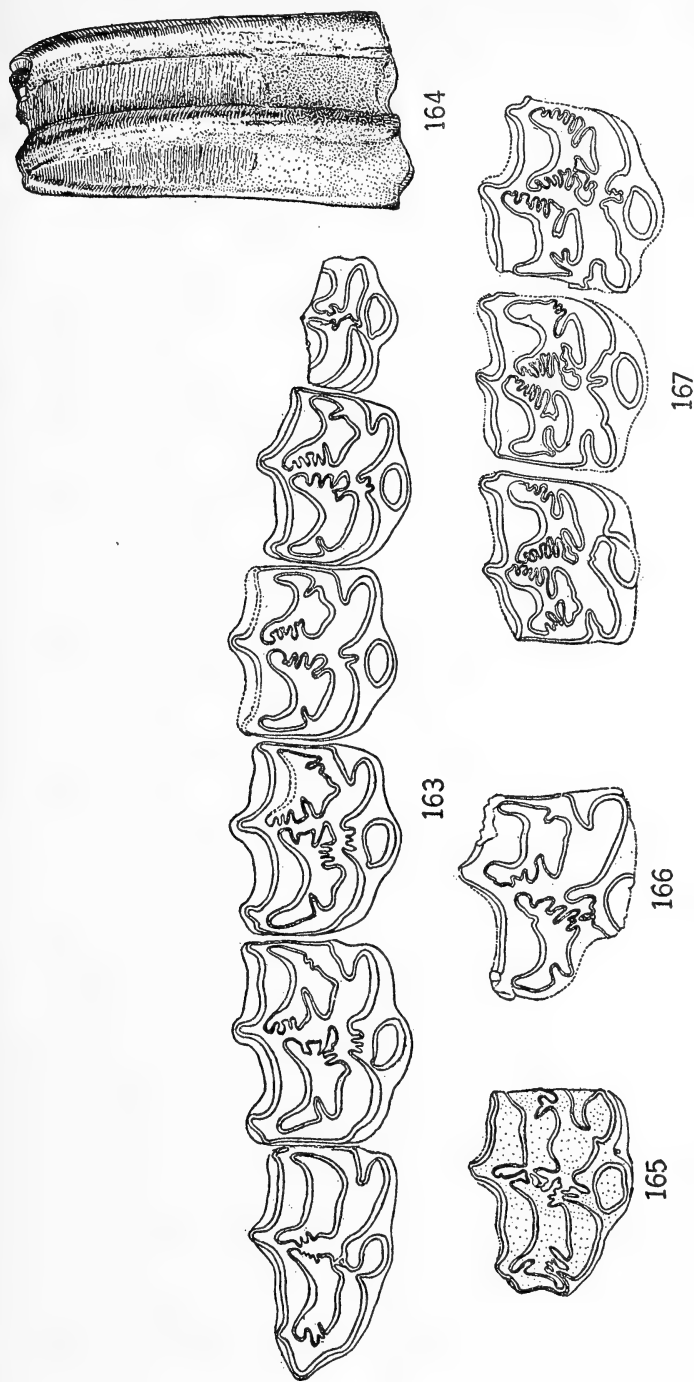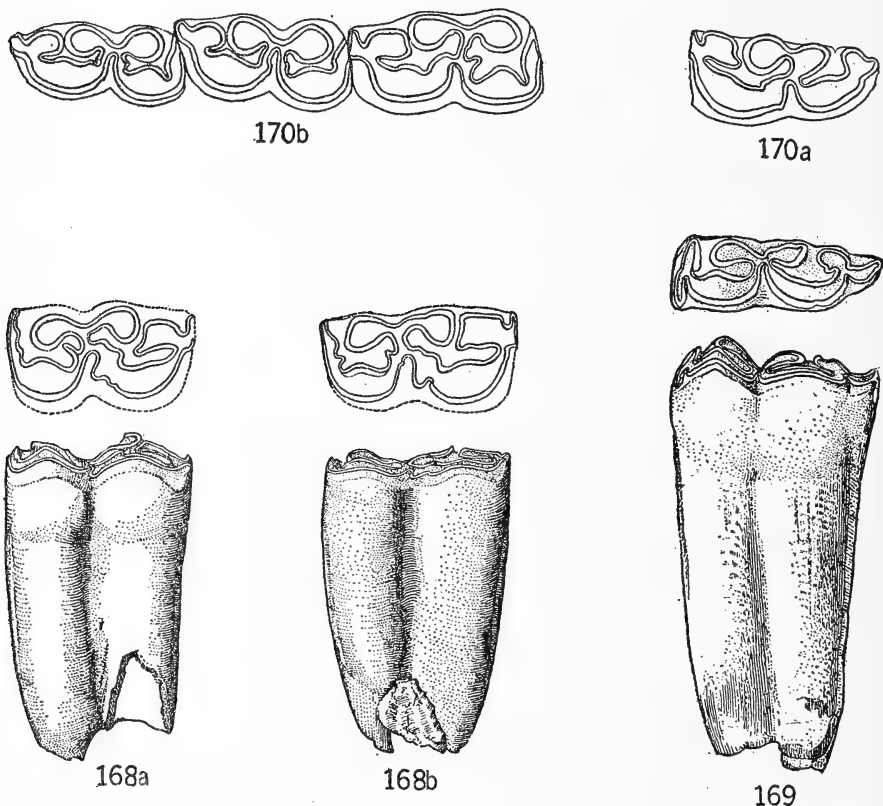
FIGS. 163 AND 164. *Hipparion mohavense* Merriam. Upper cheek-teeth, P² to M³, no. 21320, natural size. Fig. 163, occlusal view; fig. 164, P⁴, outer view. Ricardo Pliocene, Mohave Desert, California.

FIG. 165. *Hipparion*, near *mohavense* Merriam. P², no. 19438, natural size. Ricardo Pliocene, Mohave Desert, California.

FIG. 166. *Hipparion*, near *mohavense* Merriam. Upper cheek-tooth, no. 19843, natural size. Ricardo Pliocene, Mohave Desert, California.

FIG. 167. *Hipparion mohavense* Merriam. Type specimen, upper cheek-teeth, no. 19787, natural size. Ricardo Pliocene, Mohave Desert, California.

tion of a slightly different pattern of the enamel folds at the pos-
terointernal angle of the prefossette, and on the inner wall opposite
the protocone. The type specimen was found to differ from *Hip-
parion richthofeni* of China in the presence of a single fold in the

170b

170a

168a

168b

169

FIGS. 168*a* AND 168*b*. *Hipparion mohavense* Merriam. Inferior cheek-teeth associated
with type specimen, no. 19787?, natural size. Fig. 168*a*, P_4; Fig. 168*b*, P_3. Ricardo Plio-
cene, Mohave Desert, California.

FIG. 169. *Hipparion mohavense* Merriam. M_2, no. 21209, natural size. Ricardo Plio-
cene, Mohave Desert, California.

FIGS. 170*a* AND 170*b*. *Hipparion mohavense* Merriam. Lower cheek-teeth, no. 21348,
natural size. Fig. 170*a*, P_2; fig. 170*b*, P_4 to M_2. Ricardo Pliocene, Mohave Desert, Cali-
fornia.

enamel wall opposite the protocone, while in *H. richthofeni* a double
fold may appear at this point. In the specimen no. 21320 the fold
may be double as in *H. richthofeni*.

Several lower cheek-teeth associated with the type specimen (figs.

168*a*, 168*b*) of *H. mohavense* are Hipparion-like in form and cementation of the crowns, in the form of the metaconid-metastylid column, in the plications of the enamel, and in the occasional presence of the small antero-external fold. Several other specimens from the Ricardo show approximately the characters seen in this type.

The Ricardo specimens exhibit considerable variation in size and form. The extremes of difference are probably those separating the type specimen from the complete dentition represented in no. 21311 described below as *Hipparion mohavense callodonte*. The gaps are partly bridged, but it is not improbable that two or more distinct species are represented.

HIPPARION MOHAVENSE CALLODONTE Merriam

FIGURES 171 TO 175

H. m. callodonte Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, p. 54, figs. 5–7, 1915.

Type specimen no. 21311, a practically complete upper and lower dentition from locality 2281, in the upper portion of the Ricardo Pliocene, near Ricardo Post Office, California.

A finely preserved specimen (no. 21311, figs. 171–175) representing all of the elements of the cheek-tooth dentition, and several incisors, was discovered by E. M. Butterworth in 1913. This specimen shows the dentition very slightly worn, with M^3 not yet in function. The upper cheek-teeth are slightly larger than those of the *Hipparion mohavense* specimen no. 21320. The protocone shows more marked transverse flattening, the enamel pattern exhibits more numerous folds, but fewer which are deep and well rounded. Much of the difference to which attention has just been directed is evidently due to the fact that the teeth of *H. m. callodonte* are in a less advanced stage of wear. The difference in complication of the enamel folds may not be explained on this basis.

In specimen 21311 the complete lower cheek-tooth series is present with the upper series. P_4 shows incipient wear; M_3 was not yet in function. These teeth represent an individual somewhat larger than the type specimen of *H. mohavense*. The enamel is markedly folded, though not as strongly as in some specimens of *H. gracile*.

Incisor teeth associated with specimen 21311 (figs. 174, 175) show a strongly developed cupping of the enamel.
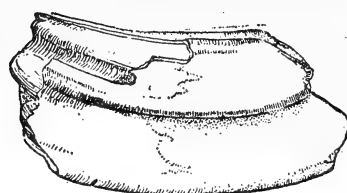
FIGS. 171 TO 173. *Hipparion mohavense callodonte* Merriam. Cheek-tooth series, type specimen, no. 21311, natural size. Fig. 171, superior cheek-teeth, occlusal view; fig. 172, M³, outer view; fig. 173, inferior cheek-teeth, occlusal view. Ricardo Pliocene, Mohave Desert, California.

MEASUREMENTS OF No. 21311

P^2, anteroposterior diameter	29.9 mm.
P^2, transverse diameter	20.2
P^3, anteroposterior diameter	27.4
P^3, transverse diameter	23.2
P^4, anteroposterior diameter	24.8
P^4, transverse diameter	21.5
P^4, height of mesostyle	45.5
M^1, anteroposterior diameter	24.5
M^1, transverse diameter	22.6
M^2, anteroposterior diameter	24
M^2, transverse diameter	20.4
M^2, height of mesostyle	41
M^3, anteroposterior diameter	21
M^3, transverse diameter	18
P_2, anteroposterior diameter	28.4
P_2, greatest transverse diameter	12
P_3, anteroposterior diameter	27
P_3, greatest transverse diameter	13.7
P_4, anteroposterior diameter	27.4
P_4, greatest transverse diameter	13
P_4, height of protoconid	51
M_1, anteroposterior diameter	25.8
M_1, greatest transverse diameter	11.4
M_2, anteroposterior diameter	27.3
M_2, greatest transverse diameter	10.8
M_2, height of protoconid	44.4
M_3, height of protoconid	44.4
M_3, greatest transverse diameter	10.4

HIPPARION, sp. A

A very large *Hipparion* P^2, no. 22303 (fig. 176), found in the Ricardo beds between the uppermost and the second basalt flows differs so much from the typical *H. mohavense* in its large size that it may represent a distinct species. The pattern of the enamel suggests in some respect the *Hipparion mohavense callodonte* form.

MEASUREMENTS OF No. 22303

P^2, anteroposterior diameter	35.6 mm.
P^2, transverse diameter	22.8

HIPPARION, sp. B

In the collection of Professor James Perrin Smith of Stanford University there is a M^2 (fig. 177) of a *Hipparion* from the upper portion of the Ricardo. This tooth is much narrower than M^2 of the type specimen of *H. mohavense*, while the enamel folds are less complicated and the protocone is more strongly compressed.
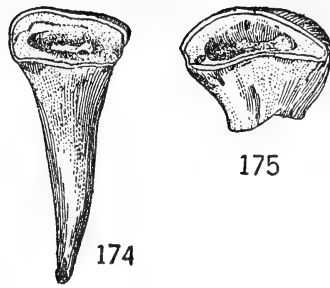
FIGS. 174 TO 175. *Hipparion mohavense callodonte* Merriam. Incisor teeth, no. 21311, natural size. Ricardo Pliocene, Mohave Desert, California.
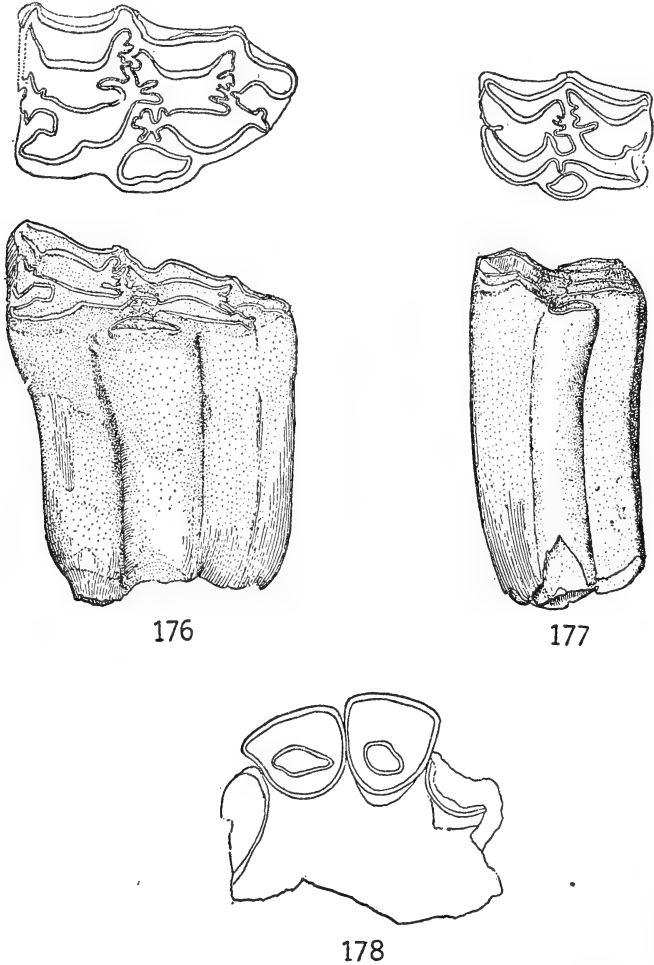
FIG. 176. *Hipparion*, sp. A. P², no. 22303, natural size. Ricardo Pliocene, Mohave Desert, California.

FIG. 177. *Hipparion*, sp. B. M², natural size. Ricardo Pliocene, Mohave Desert, California.

FIG. 178. *Pliohippus?*, sp. Incisor teeth, no. 22510, natural size. Ricardo Pliocene, Mohave Desert, California.

This form may be as near to the Tejon Hills *Neohipparion*, near *molle*,[40] as it is to *Hipparion mohavense*. It shows characters which possibly set it off as a species distinct from other forms of this genus known in the Mohave area.

COMPARATIVE MEASUREMENTS

	Hipparion sp. B	Neohipparion near molle No. 21781 Chanac	H. mohavense No. 21320
M², anteroposterior diameter	21.3 mm.	17.8	22.3
M², transverse diameter at summit	15.8	a12.8	20.2
M², height of slightly worn crown	a42	a40.5	45.6

a, approximate.

RELATIONSHIPS OF RICARDO HIPPARIONS

The affinities of the Ricardo *Hipparion* species to the Old World forms cannot be determined with full satisfaction on the basis of dentition alone, but the relation between dentition and limb structure in the Ricardo material is as yet so indefinite as to make comparisons based upon dentition less dangerous than when combined with discussion of limbs of doubtful relationship.

The hipparions from the Ricardo do not seem to correspond exactly in specific characters to any described American species known east of the Great Basin region. The nearest forms are found in the group of species including *Hipparion plicatile* and *H. ingenuum* of the Florida Pliocene, *H. venustum* of Ashley River, South Carolina, and *Neohipparion occidentale* of the Great Plains region. Of these *H. venustum* and *H. ingenuum* represent much smaller forms than those of the Ricardo. *H. plicatile* is slightly smaller than *H. mohavense*, the crowns seem somewhat shorter anteroposteriorly, the fossettes are smaller, and the outer faces of the paracone and metacone pillars are much more distinctly concave than in the Ricardo species. On the whole these three Atlantic Coast species differ more widely from the Old World hipparions than do the Ricardo forms.

Of the American species grouped by Gidley under *Neohipparion*, *N. occidentale* shows tooth dimensions approaching those of the Ricardo specimens, but probably ranges to larger size than the Ricardo forms. Compared with *H. mohavense* the protocone of

[40] Merriam, J. C., Mammalian remains from the Chanac Formation of the Tejon Hills, California, Univ. Calif. Publ., Bull. Dept. Geol., vol. 8, p. 120, 1916.

N. occidentale is commonly much longer anteroposteriorly and much more compressed laterally, and the enamel bordering the fossettes generally shows less marked plications. The type of *H. mohavense callodonte* from Ricardo approaches the American *Neohipparion* more closely than does the typical material of *H. mohavense*. The protocone is somewhat flatter, the enamel may show somewhat shallower plication in the upper molars, and the folds may be more distinctly angular. This specimen is not however referable to any previously described American species, and it is near an Old World type.

The closest affinities of *Hipparion mohavense* are evidently with the Old World species of the East Asiatic *H. richthofeni*, and the European *H. gracile* type, rather than with the typical American species grouped in *Neohipparion*. Even the form seen in *H. plicatile* of Florida is not as near the Ricardo species as are the Chinese and European representatives of this genus.

According to Schlosser[41] the upper cheek-teeth of *H. gracile* are commonly distinguished from those of *H. richthofeni* by a relatively short and broad posterior valley, a smaller and more nearly circular protocone, and by the form of the small fold of the inner wall opposite the protocone. In all of these characters *H. mohavense* is nearer to *H. richthofeni* than to *H. gracile*.

In the original description of *Hipparion mohavense* the writer suggested that diagnostic characters separating it from the Chinese hipparions in the upper molars were found in the form of the small fold opposite the protocone, and in the length of the molars. Additional material now available shows that the small enamel fold opposite the protocone may have approximately the same form in the two species, though it probably tends to be more complex in the Chinese form. The new material available for study indicates also that the difference in length of the cheek-teeth is very small. Measurements of the largest specimens of *H. richthofeni* are somewhat greater in length of crown than in the Ricardo material, but the difference is slight. More noticeable than contrast in length of crown is the excess in area of the cross-section of the largest cheek-teeth of *H. richthofeni*.

With the collections now available few if any clearly diagnostic

[41] Schlosser, M., Abh. d. Mat. Phys. Kl. Bayr. Akad. Wiss., Bd. 22, S. 84, 1906.

characters in form or pattern of the Ricardo teeth designated as *H. mohavense* appear which may be considered as certainly separating them from the Chinese *H. richthofeni*. The most suggestive differences between the two are in dimensions, but this variation is inconsiderable. Were the specimens examined not found so widely separated geographically as to make specific identity seem highly improbable, the writer would be inclined to include the Ricardo forms in the *H. richthofeni* group. Geographic situation and the suggested differences in dimensions make it practically certain that the Ricardo species is distinct from *H. richthofeni*, but the marvel is that the two approach so closely. It should be remarked in passing over this subject that some of the characters which have been used to separate *H. richthofeni* from *H. gracile* seem to disappear with the study of large collections. It is probable, however, that as these characters disappear others not previously observed will present themselves.

In many respects *Hipparion mohavense callodonte* of the Ricardo *Hipparion* group resembles a type from the island of Samos, which has been referred to *H. gracile*. In this Samos form the protocone is much more strongly compressed than in typical *H. gracile*, and exceeds the degree of flattening in *H. m. callodonte*. The enamel folds are complicated much as in *H. gracile*, *H. richthofeni*, and *H. mohavense*.

ORIGIN OF RICARDO HIPPARIONS

The close similarity of the Ricardo hipparions to the types in existence at approximately the same time in Asia and Europe is probably not to be explained on any hypothesis other than that of common origin. As the gap between *Hipparion* and the brachyodont horses seems more clearly bridged in America than in Europe, there is good reason for looking to America or some intermediate region for the ancestors of this group. Among the species assembled in the North American genus *Merychippus* there are a number of forms that are very close to *Hipparion*, and that seem in their evolution to trend directly toward that type. From available evidence it appears probable that *Hipparion* is derived from the *Merychippus* group.

With special reference to the origin of the Ricardo species it seems worth noting that there is present in the Upper Miocene

Barstow fauna of the Barstow syncline an advanced form of *Mery-chippus* differing but little from *Hipparion*. In the Barstow *Mery-chippus* the crowns are a little shorter, they are more strongly curved, the mesostyle is relatively heavier at the proximal end, the enamel folds are less complex, and the cement is a little less abundant than in *H. mohavense*. While it is improbable that the known *Hipparion* forms of the Ricardo fauna are descended directly from any known Hipparion-like species of *Merychippus* of the Barstow fauna, the proximity of the two in morphologic characters, geographic situation, and in time, strongly suggest close relationship. Very much of the palaeontologic history of the Great Basin and Pacific Coast regions is still unknown. The portions that are not yet known vastly exceed the material available, and much of the Miocene record is still to be discovered. In the present state of our knowledge we may consider as reasonable the view that a line of descent may yet be traced from a form near a Barstow *Mery-chippus* to a Ricardo *Hipparion*.

COMPARATIVE MEASUREMENTS OF HIPPARION DENTITION

	H. mohavense, no. 21320, moderately worn, M³ in function	H. mohavense callodonte, no. 21311, slightly worn, M³ not in function	H. mohavense, Type, no. 19787	H. richthofeni, after Schlosser	H. richthofeni, after Schlosser	H. richthofeni, after Schlosser	H. gracile, after Weithofer	H. ingenuum, Florida Pliocene	H. plicatile, Florida Pliocene
P², anteroposterior diameter	29 mm.	29.9	....	34	29	31	....	....	....
P², transverse diameter	19.6	20.2	....	24	22	22	....	....	....
P³, anteroposterior diameter	25	27.4	22	27	24	23	23.8	....	....
P³, transverse diameter	22.4	23.2	23	28	24	23	23	....	....
P³, height of mesostyle	43	....	....	40	....	....	....	....	....
P⁴, anteroposterior					mid. age				
P⁴, anteroposterior diameter	24	24.8	....	....	....	22.5	22.2	....	....
P⁴, transverse diameter	22	21.5	....	....	....	23	21	....	....
P⁴, height of mesostyle	47.5	45.5	....	....	....	....	....	....	....
M¹, anteroposterior diameter	22.3	24.5	21.4	27.5	23.5	20	20.5	....	M¹? 20
M¹, transverse diameter	21.5	22.6	22	22	20	19	20.7	....	M¹? 23
M², anteroposterior diameter	22.3	24	21.6	27.5	23.5	20	20.5	18.5	....
M², transverse diameter	20.2	20.4	20	22	20	19	17.2	16.5	....
M², height of mesostyle	44	41	33.5	56	....	....	....	43	....
M³, anteroposterior diameter	19.7	21	....	24	19	29	....	....	....
M³, transverse diameter	16.9	18	....	19.5	18	22	....	....	....

COMPARATIVE MEASUREMENTS OF HIPPARION DENTITION—*Continued*

	H. m. callodonte no. 21311, beginning wear, M₂ not in function	Associated with H. mohavense, no. 19787, Type	H. mohavense, no. 21348	H. richthofeni, after Schlosser	H. richthofeni, after Schlosser	H. richthofeni, after Schlosser	H. gracile, after Weithofer	H. gracile, after Weithofer
P₂, anteroposterior diameter	28.4 mm.....		23.8	a29.3	25	24	23	30.7
P₂, greatest transverse diameter	12	....	11.4	15	12	11	12	12.1
P₃, anteroposterior diameter	27	23.5	....	27	22	21	27	26.7
P₃, greatest transverse diameter	13.7	11.7	....	16.5	14.5	12	12.8	13.7
P₃, height of protoconid	....	....	....	46	....	..	....	....
P₄, anteroposterior diameter	27.4	23.8	24.2	25	19.5	20	25	25.1
							cut end	cut end
P₄, greatest transverse diameter	13	11.9	12.9	16.5	13	12	11	13.8
P₄, height of protoconid	51	32	44	47	....	..	....	....
M₁, anteroposterior diameter	25.8	....	21.5	28	22	20	25.8	24.6
M₁, greatest transverse diameter	11.4	....	12.1	15 no. 21209	14	13	10.8	12.2
M₂, anteroposterior diameter	27.3	....	22	26.2	27	23	25	23.1
M₂, greatest transverse diameter	10.8	....	11.3	11	13	11	9.9	10.1
M₂, height of protoconid	44.4	....	....	50 no. 19849	56	54	....	....
M₃, anteroposterior diameter	25	....	....	24.3	24	31	24	27.9
M₃, greatest transverse diameter	10.4	....	....	10	11	13	a8	9.8
I, anteroposterior diameter	8	....	....	....	....	..	....	....
I, greatest transverse diameter	15	....	....	....	....	..	....	....

a, approximate.

While we are as yet very far from a situation in which we can hope to establish anything like a fully satisfactory time correlation between the West American Tertiary formations and those of Europe or even of Asia, there are reasons for believing that the Ricardo fauna represents a time near the beginning of the Old World Pliocene, and the Barstow fauna an epoch corresponding approximately

to Upper Miocene. If these suggestions are approximately correct there is a possibility that the Old World hipparions are derived from an American stock of which the Ricardo group was a part. Or it may be that the Ricardo fauna was only a surviving remnant of this stock occupying a limited area on the Pacific border of the continent. The great number of American forms grouped under *Neohipparion* may be derived from an original typical *Hipparion* group, or they may have originated independently from another branch of *Merychippus*. The forms of the Florida Pliocene, including *Hipparion plicatile*, may be an Atlantic survival of the original American *Hipparion* group differing from the western forms partly because of geographic separation.

PLIOHIPPUS TANTALUS Merriam

Protohippus? tantalus Merriam, Univ. Calif. Publ., Bull. Dept. Geol., vol. 7, p. 440, figs. 4a and 4b, 1913.

Type specimen (fig. 189) an upper premolar, no. 19434, Ricardo beds, Mohave Desert, California.

Crowns of upper cheek-teeth moderately curved. Unworn crowns probably with a longitudinal diameter exceeding twice the transverse measurement. Protocone connected with protoconule. Anterior and posterior fossettes wide, with enamel moderately folded on their adjacent borders. Mesostyle narrowing very slightly above the base, apparently somewhat heavier than in *Pliohippus mirabilis* and *P. supremus*.

A complete but somewhat worn, upper cheek-tooth dentition (no. 22308, fig. 179) from locality 2065 in the middle portion of the Ricardo section represents a *Pliohippus* form in which the protocone is relatively narrower transversely than in *P. fairbanksi*, and the fossettes are wider. While these characters may be due in a considerable part to wear, the specimen suggests *P. tantalus* rather than *P. fairbanksi*.

Two practically complete series of lower cheek-teeth (figs. 180–182) from the lower half of the section at Ricardo represent a *Protohippus* or *Pliohippus* form, the relationship of which to the described upper cheek-teeth has not as yet been certainly determined. This species is apparently distinct from a larger, heavier type tentatively determined as *P. fairbanksi*. These less massive teeth, in which the metaconid-metastylid column is somewhat longer anteroposteriorly and the inner gutter wider than in the larger form, are referred tentatively to *Pliohippus tantalus*. Of

the two lower dentitions referred to *P. tantalus*, no. 21789 was found between the uppermost and the second basalt flows $2\frac{1}{2}$ miles
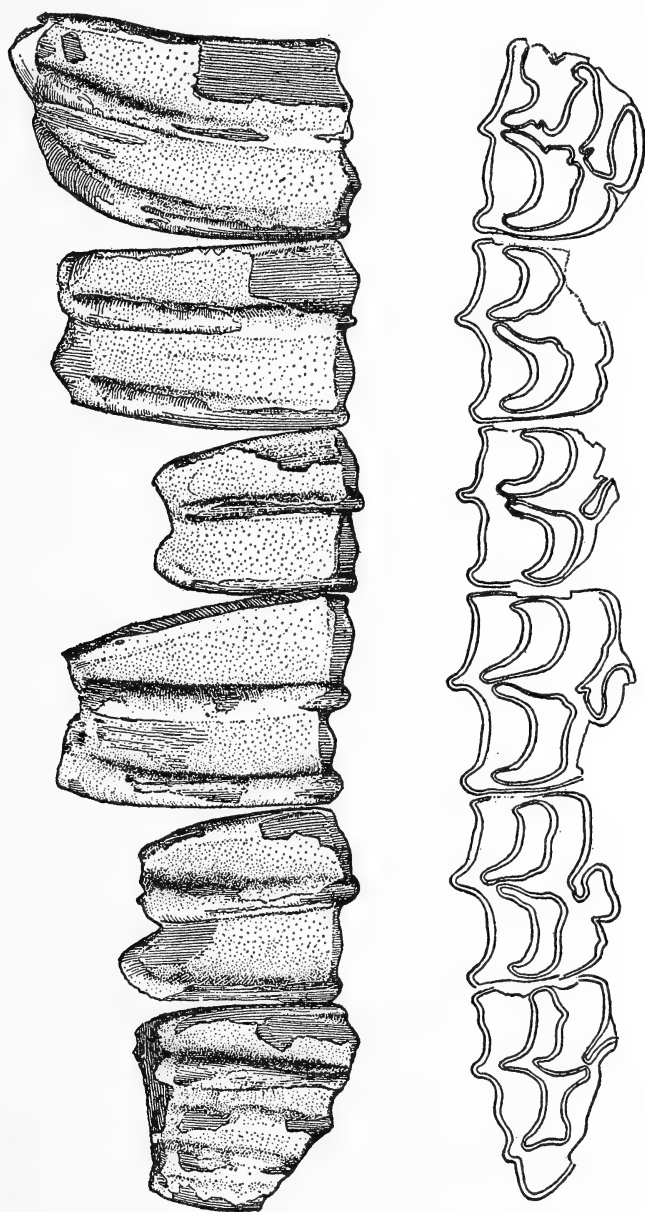
FIG. 179. *Pliohippus tantalus?* (Merriam). Superior cheek-tooth series, no. 22308, lateral and occlusal views, natural size. Ricardo Pliocene, Mohave Desert, California.

north of Ricardo Post Office; no. 21790 was found by J. P. Buwalda about 500 feet below the lowest basalt flow and 400 feet above the base of the Ricardo beds, two miles above the mouth of Iron Cañon.

In no. 21789 (figs. 180, 181) the moderately worn tooth crowns are long and heavily cemented. Compared with no. 21346, a large *Pliohippus* specimen from a much higher situation in the Ricardo, the crowns are relatively much narrower with approximately the
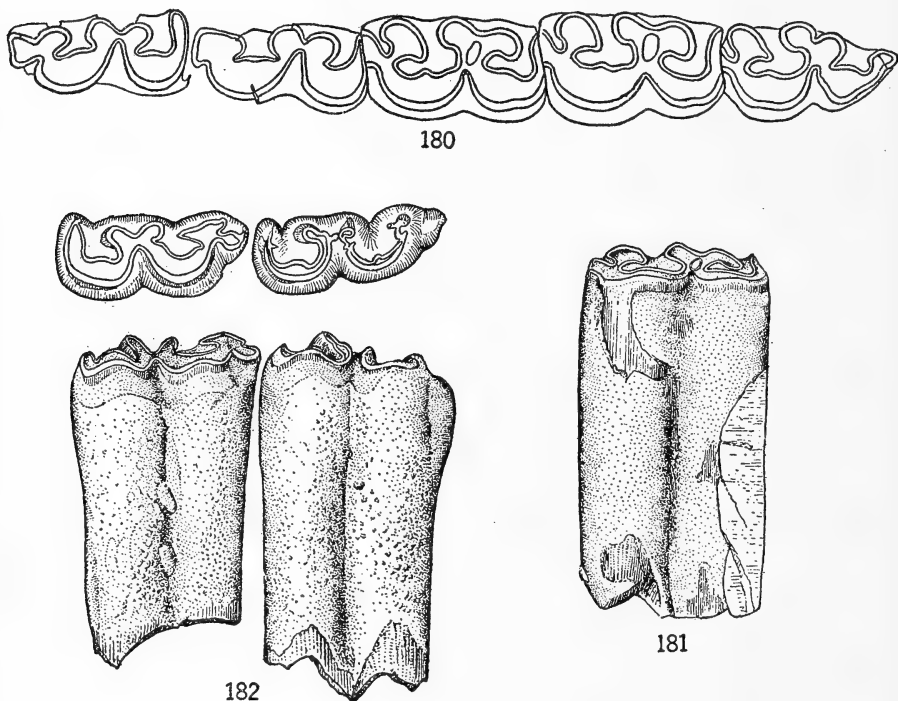
FIGS. 180 TO 182. *Pliohippus tantalus?* (Merriam). Inferior cheek-teeth, × $\frac{5}{6}$. Fig. 180, P_2 to M_2, no. 21789, occlusal view; fig. 181, P_4, no. 21789, outer view; fig. 182, M_1 and M_2, no. 21790, outer and occlusal views. Ricardo Pliocene, Mohave Desert, California.

same anteroposterior diameter. The metaconid-metastylid column in no. 21789 is noticeably narrower than in the later form.

In no. 21790 (fig. 182) the characters seem much as in no. 21789, but the permanent teeth are shown by wear only in the case of M_1. In no. 21790 the milk premolars are still in position, though almost worn away. The temporary teeth show a clearly marked cement deposit on the best preserved individuals.

Pliohippus tantalus is near *P. supremus*, in character of upper cheek-teeth, but seems to have wider fossettes with a different type of enamel folds. The mesostyle of the Ricardo type appears slightly heavier than that of the type specimen of *P. supremus*, which is a tooth of approximately the same size and of similar situation in the dental series.

Upper cheek-teeth of *Pliohippus* from the Thousand Creek Pliocene are near the stage of evolution in this Ricardo form, but the material from Thousand Creek is fragmentary, and a better representation of the species is needed before a thoroughly satisfactory comparison can be made.

The *Pliohippus* forms from the Lower Etchegoin and Jacalitos of the Great Valley of California all have narrower upper cheek-teeth with smaller fossettes than in *P. tantalus*.

PLIOHIPPUS FAIRBANKSI Merriam

Pliohippus fairbanksi Merriam.   Univ. Calif. Publ., Bull. Dept. Geol., vol. 9, p. 55, figs. 8a–8c, 1915.

Type specimen (fig. 185) an upper cheek-tooth, P^4?, no. 19789, from the Ricardo Pliocene near Ricardo Post Office, California.

Crowns of upper cheek-teeth heavily cemented and strongly curved. Protocone small, nearly circular in cross-section in premolars. Anterior notch between protocone and protoconule sharp. Union of metaloph and protoloph commonly effected by confluence of the posterior horn of the protoconule and a crochet external to it. Borders of fossettes simple.

This species differs from *Pliohippus tantalus* mainly in form of protocone and fossettes. The protocone is of the short, round type seen in *P. interpolatus*, while that of *P. tantalus* is presumed to show more compression. The fossettes in the type specimen are narrow and more distinctly lunate than in *P. tantalus*, and do not show less marked plications of their walls.

Specimen no. 21346 (fig. 183) representing the greater part of a *Pliohippus* lower cheek-tooth dentition from the upper portion of the Ricardo shows the crowns larger and heavier than those from the lower and middle portion of the section referred to *P. tantalus*, and the metaconid-metastylid column presents a sharper, narrower, inner gutter. The form represented by no. 21346 is presumably distinct from the specimens referred to *P. tantalus*. It may be referred tentatively to *P. fairbanksi*, but possibly represents a third type in the Ricardo fauna.
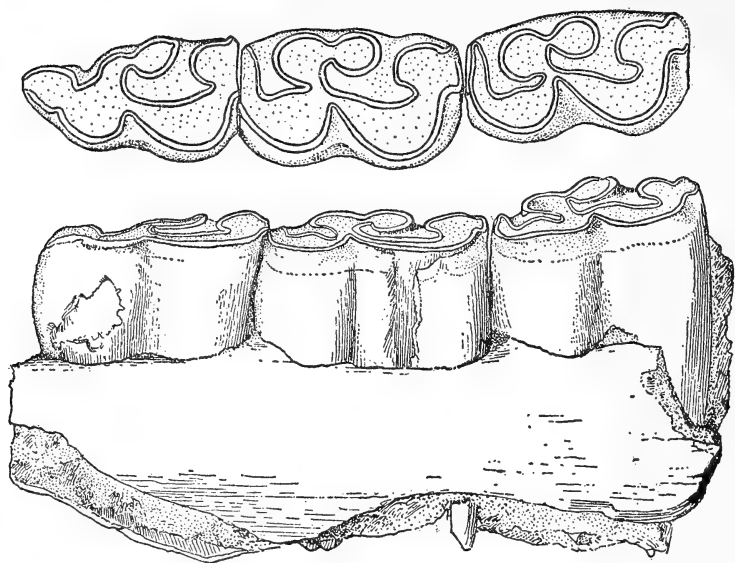
FIG. 183. *Pliohippus fairbanksi?* Merriam.   P$_2$ to P$_4$, no. 21346, natural size.   Ricardo Pliocene, Mohave Desert, California.

COMPARATIVE MEASUREMENTS

	P. fairbanksi, Ricardo, Type, no. 19789	P. fairbanksi, no. 22307	P. fairbanksi, J. P. Smith specimen	P. coalingensis, Etchegoin, no. 21341	P. tantalus, Type, no. 19434
P^3, anteroposterior diameter	....	....	25.2	....	....
P^3, transverse diameter	....	....	26	....	....
P^4, height of crown, outer side	55 mm.	51.5	....	53	48
P^4, anteroposterior diameter	25	25.6	24.8	27.2	24.8
P^4, transverse diameter	26.4	25	26.7	24.4	24
M^1, anteroposterior diameter	....	....	22	....	....
M^1, transverse diameter	...	....	25.2	....	....

MEASUREMENTS OF No. 21346

Length anterior border P$_2$ to posterior border P$_4$...................... 85.5 mm.

P$_2$, anteroposterior diameter.................................... 29

P$_2$, transverse diameter.. 15.2

P$_3$, anteroposterior diameter.................................... 27.9

P$_3$, transverse diameter.. 15.2

P$_4$, anteroposterior diameter.................................... 29.6

P$_4$, transverse diameter.. 15.5

M$_1$?, anteroposterior diameter.................................. 25.5

M$_1$?, transverse diameter.. 14.2

The upper cheek-teeth of *Pliohippus coalingensis* from the Lower Etchegoin on the western border of the San Joaquin Valley show rather narrow fossettes, a very small, round protocone, and a weak connection of protoloph and metaloph. The Etchegoin species has considerably narrower and less curved teeth than the Ricardo form, and is presumably specifically different.

The crowns of upper cheek-teeth of *Pliohippus* from the Thousand Creek Pliocene show about the same curvature as in no. 19789, and the size is approximately the same. The fossettes are larger in the Thousand Creek form, but there is not sufficient material available for a fully satisfactory comparison. The protocone is not well shown in the Thousand Creek specimens.

PLIOHIPPUS, sp. A, near MIRABILIS (Leidy)

A single tooth, M^1 (no. 21323, fig. 188), from Ricardo represents a form presumably to be assigned to *Pliohippus*, but not certainly identical with either *P. tantalus* or *P. fairbanksi*. Compared with the described forms from the Ricardo, the crown of no. 21323 is smaller and narrower, the fossettes are simpler, and the mesostyle is a little lighter than in *P. tantalus*. As this specimen is evidently M^1 considerably worn, while the *P. tantalus* type may be a P^4 in a less advanced stage of wear, it is possible that position, wear, and individual variation may account for the difference between no. 21323 and the type of *P. tantalus*. On the other hand the smaller size suggests that later collections from Ricardo should be carefully examined for a species smaller than *P. tantalus*. The form represented by no. 21323 evidently possessed characters verging on those of *Pliohippus mirabilis*.

MEASUREMENTS OF No. 21323

M^1, anteroposterior diameter.................................... 21.4 mm.
M^1, transverse diameter... 21.7
M^1, height of portion of crown remaining, measured along mesostyle... 36

PLIOHIPPUS MILK DENTITION

Several milk teeth of *Pliohippus* are present in the collection from the Ricardo. The crowns are subhypsodont and heavily cemented. Even in very slightly worn specimens the small protocone is lightly connected with the protoconule. The enamel bordering the fossettes shows very few plications in a moderately worn
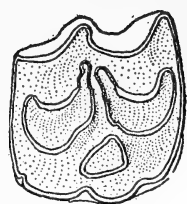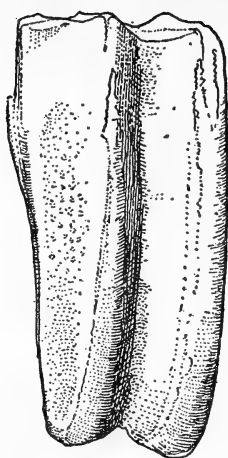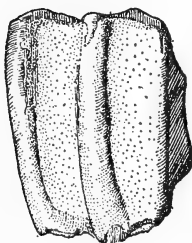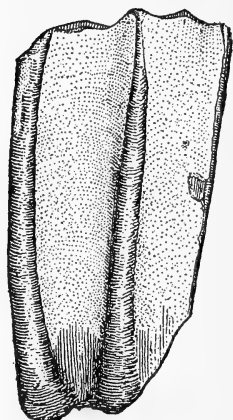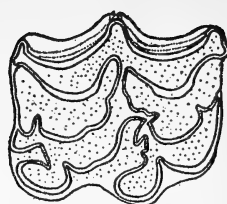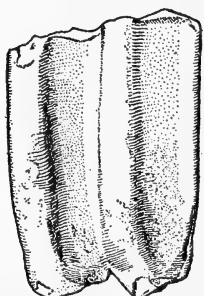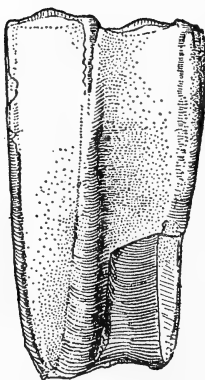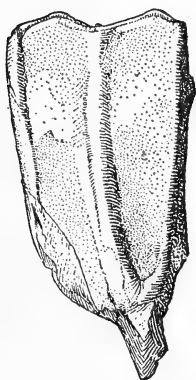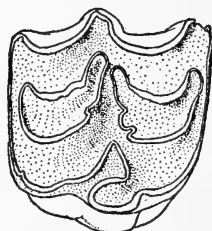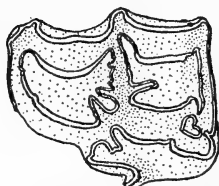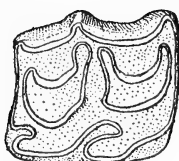
FIGS. 184 TO 187. *Pliohippus fairbanksi* Merriam. Superior cheek-teeth, outer and occlusal views, natural size. Fig. 184, P⁴, no. 22307; fig. 185, type specimen, P⁴?, no. 19789; fig. 186, M¹; fig. 187, P⁴. Ricardo Pliocene, Mohave Desert, California.

FIG. 188. *Pliohippus*, sp. A, near *mirabilis* (Leidy). M¹, no. 21323, natural size. Ricardo Pliocene, Mohave Desert, California.

FIG. 189. *Pliohippus tantalus* (Merriam). P⁴?, type specimen, no. 19434, natural size. Ricardo Pliocene, Mohave Desert, California.

tooth.   These teeth resemble in general the form of milk premolars in *Pliohippus supremus*.   It is not certain which of the Ricardo species of *Pliohippus* these teeth represent.

MEASUREMENTS OF UPPER MILK MOLARS

	No. 21199
Dm^4, anteroposterior diameter	26.5 mm.
Dm^4, height of slightly worn crown, measured on protocone	14

	No 19443
Dm^3?, anteroposterior diameter	24.5
Dm^3?, height of somewhat worn crown, measured on protocone	9

191

190   192
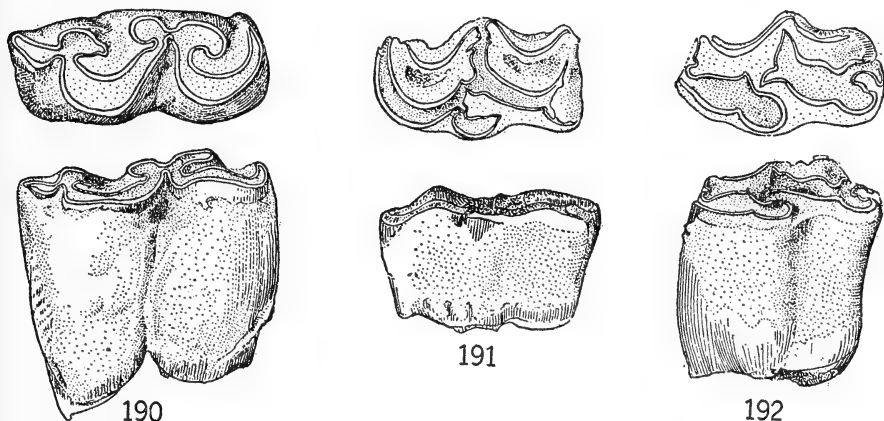
FIG. 190.   *Pliohippus fairbanksi?* Merriam. Dm_4, no. 21315, natural size.   Ricardo Pliocene, Mohave Desert, California.

FIGS. 191 AND 192.   *Pliohippus fairbanksi?* Merriam.   Superior milk molars, natural size.   Fig. 191, Dm^4, no. 21199; fig. 192, no. 21210.   Ricardo Pliocene, Mohave Desert, California.

In a large lower milk molar (no. 21315, fig. 190), the crown is high and narrow and shows a thick cement layer.   The parastylid extends inward beyond the metaconid.   The metaconid-metastylid column is narrow transversely in the section exposed, and the gutter is narrow.   This specimen probably represents the same species as the large lower teeth no. 21346 referred to *P. fairbanksi*.

MEASUREMENTS OF No. 21315

Dm_4, anteroposterior diameter	32	mm.
Dm_4, transverse diameter	12	
Dm_4, height of crown	26.6	

EQUID SKELETAL ELEMENTS

A number of limb bones from Ricardo represent horses considerably larger and of more advanced type than those from the beds of

the Barstow syncline. The phalangeal elements and the metapodials represent at least two horse types. In 21200 (fig. 195) the proximal phalangeal element is larger and more slender than in any of the *Merychippus* or *Protohippus* forms from the Barstow. It is longer and much more slender than in *Hypohippus*. It is smaller and much more slender than in *Equus*. It closely resembles the proximal phalanges of *Pliohippus pernix*, the type of the genus *Pliohippus*. It is somewhat more slender and much larger than the corresponding element in *Neohipparion whitneyi*. Whether the specimen is to be referred to *Hipparion*, *Neohipparion*, or *Pliohippus* is uncertain, but the relation to *Pliohippus* seems close.

In no. 21197 (fig. 196) the proximal phalangeal element is shorter and much less slender than in no. 21200. It is also larger than in any of the forms like *Protohippus* or *Merychippus* from the Barstow beds, and is relatively wider than the Barstow forms. This element is nearer the form of the corresponding element in *Hypohippus*, but is longer and more slender than any proximal phalanx of *Hypohippus* known to the writer, and much more slender than elements from the Barstow fauna which are apparently to be referred to *Hypohippus* (see figs. 29, 30). This element is near the form of the proximal phalanx in *Hipparion theoboldi* of the Siwalik beds, but is more slender and smaller than in *H. theoboldi*.

Several metapodials represent a species much larger than any form from the Barstow. A second and somewhat smaller form is possibly represented by a single specimen, no. 21201. The distal end of a single metapodial, no. 21478 (fig. 202), represents a form possibly larger and distinct from the others.

In the more common form the shaft of metapodial III is considerably larger than in any specimen from the Barstow beds, and is much heavier than in the average *Merychippus* or *Protohippus* species.

In two specimens representing metacarpal III (nos. 21202, fig. 194, and 21203, figs. 193*a*, 193*b*) lateral elements are shown. In the proximal articulation the large unciform facet on metacarpal III meets the magnum facet at an angle ranging from 128° to 131°. The magnum-unciform angle is from ten to twenty degrees wider than that in the Barstow horses and seems uniformly to separate the Ricardo forms from the less progressive Barstow species. Metacarpal II stands relatively higher at the proximal end
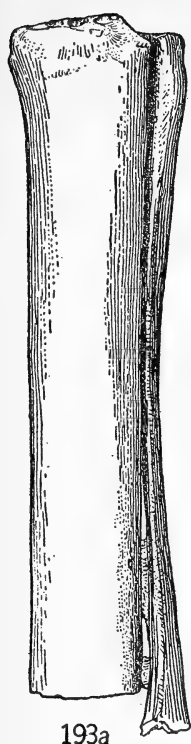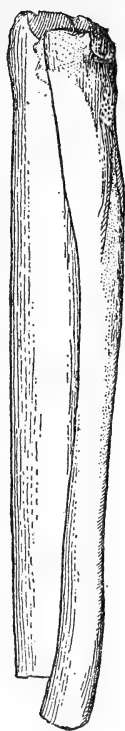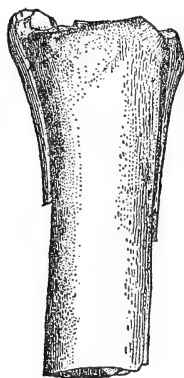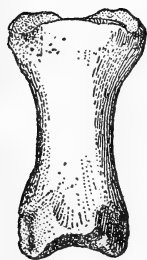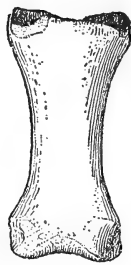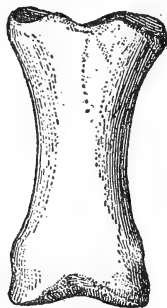
FIGS. 193a AND 193b. *Pliohippus?*, sp. Third metacarpal and lateral metacarpal, no. 21203, $\times \frac{1}{2}$. Fig. 193a, anterior view; fig. 193b, side view. Ricardo Pliocene, Mohave Desert, California.

FIG. 194. *Pliohippus?*, sp. Third metacarpal with lateral metacarpals, no. 21202, $\times \frac{1}{2}$. Ricardo Pliocene, Mohave Desert, California.

FIGS. 195 TO 199. *Hipparion* and *Pliohippus*. Phalanges, $\times \frac{1}{2}$. Fig. 195, first phalanx, no. 21200; fig. 196, first and second phalanges, no. 21197; fig. 197, second phalanx, no. 22255; fig. 198, first phalanx, no. 23126; fig. 199, first phalanx, no. 23127. Ricardo Pliocene, Mohave Desert, California.

than in *Equus*, and the facet between magnum and metacarpal II is inclined about twenty degrees away from a plane normal to the distal facet of the magnum.

If a rudimentary metacarpal I was present it was exceedingly minute, as there is scarcely a suggestion of a face of contact on the
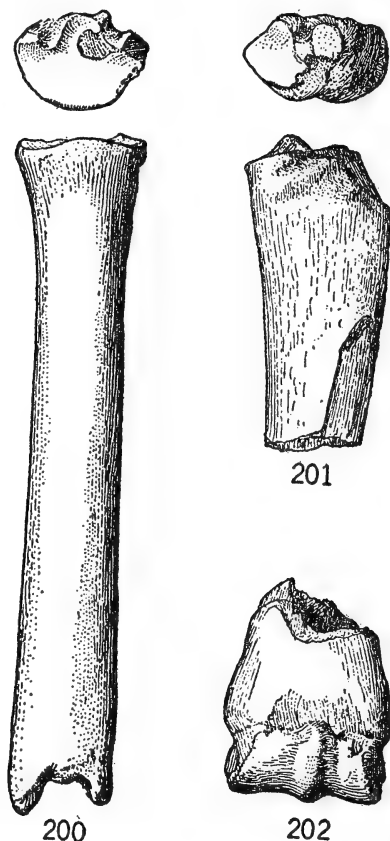
Fig. 200. *Pliohippus?*, sp. Third metatarsal, no. 21201, × ½. Ricardo Pliocene, Mohave Desert, California.

Fig. 201. *Pliohippus?*, sp. Fourth metatarsal?, no. 21480, × ½. Ricardo Pliocene, Mohave Desert, California.

Fig. 202. *Pliohippus?*, sp. Distal end of third metapodial, no. 21478, × ½. Ricardo Pliocene, Mohave Desert, California.

inner side of the proximal end of metacarpal II. Metacarpal IV is represented for at least two-thirds of its length in specimen no. 21203. The lateral side of the proximal end shows a distinct facet for a metacarpal V.

In a metatarsal III (no. 21198, figs. 203*a*–203*d*) the beveled pos-

tero-lateral regions with large contact faces show that lateral metatarsals II and IV extend as fairly large elements down almost to the distal end of this element.   A portion of the large metatarsal IV is coössified with the shaft of metatarsal III near the middle of this specimen.   The median distal keel extends over the anterior portion of the distal articular face as a clearly defined ridge, reaching quite to its proximal border.   The distal keel is more strongly marked in this form than in any of the numerous specimens from the Barstow.

On the proximal end of a metatarsal III (no. 21198, fig. 203*b*), the cuboid facet is large, and is only slightly inclined away from the plane of the ectocuneiform facet.   There is a well marked facet for the mesocuneiform showing but little more inclination away from the plane of articulation of the metapodial and ectocuneiform than is shown in the facet between cuboid and metapodial.   The lunate posterior portion of the articulation between metapodial and ectocuneiform is separated from the larger anterior surface by a deeply pitted area.

A single metatarsal III, no. 21201 (fig. 200) represents a type somewhat different from that seen in no. 21198.   The shaft in specimen 21201 is more slender and evidently smaller.   The proximal end is relatively narrower anteroposteriorly.   The facet for the mesocuneiform is slightly larger and more nearly parallel with the plane of the ectocuneiform facet.   The posterior articulation with the ectocuneiform is not separated as a distinct lunate facet as in no. 21198, but is connected with the anterior portion of the articulation at its inner or medial end.

Metatarsal IV is shown complete in no. 21475 (fig. 204).   It is considerably shorter and heavier than in *Neohipparion whitneyi*. The distal end has a large facet for support of a phalanx.   This specimen evidently belongs with a metatarsal III as large as that seen in no. 21198.   In no. 21476, a metatarsal IV is seen associated with a metatarsal III apparently of the same type as that in no. 21198.   In no. 21476, the proximal end of metatarsal IV is somewhat thinner than in 21475 and the proximal articulation with the cuboid is divided into two facets instead of being a single facet, as shown in no. 21475.   This difference may have some significance in specific or generic diagnosis or may be merely individual.
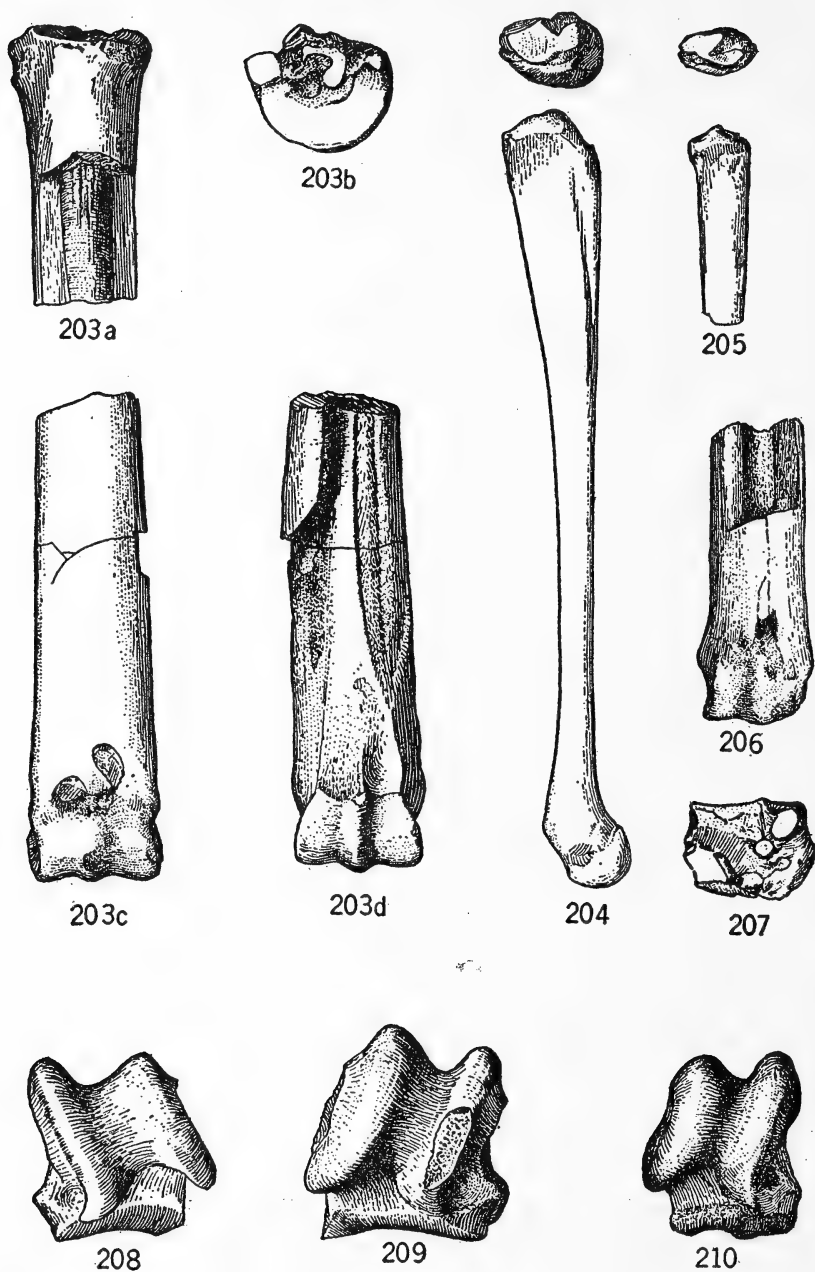
FIGS. 203a TO 203d. *Hipparion* or *Pliohippus*, sp. Third metatarsal, no. 21198, × ½. Fig. 203a, anterior view of proximal end; fig. 203b, articular facets of proximal end; fig. 203c, anterior view of distal half; fig. 203d, posterior view of distal half. Ricardo Pliocene, Mohave Desert, California. (See facing page for figure legends 204–210)

Metatarsal II is seen in no. 21479 (fig. 205).   It is much smaller than metatarsal IV.   There is no evidence indicating the presence of metatarsals I and V.

A single specimen, no. 21480 (fig. 201), seems to represent a metatarsal IV nearly twice the size of the other specimens from the Ricardo region.   It differs from those of the large horses in the marked concavity of the surface of articulation for the cuboid. This surface curves upward sharply to the summit of a sharp spine or prominence on the inner side of the proximal end of the bone and immediately behind the facet for articulation with meta-carpal III.   There is also a possible difference from metatarsal IV of the horses described in the absence of a posterior inner face for articulation with metatarsal III.   The relationship of this speci-men is uncertain.

The equid astragali from the Ricardo region are larger than any from the Barstow excepting a large Barstow specimen presumably representing *Hypohippus*.   Of the specimens available for compari-son the Ricardo astragali most nearly resemble certain specimens from the Thousand Creek Pliocene which represent a *Pliohippus* or a Hipparion-like form.   The range in size among the Ricardo astragali is considerable (figs. 208–210), and it is probable that two species or two genera are represented by this range, which seems also to be indicated by a difference in form.

The proximal end of metatarsal III, no. 21198, in its dimensions resembles that of *Hipparion*, as figured by Weithofer.[42]   In speci-mens of metatarsal III available from Ricardo the middle portion

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Figs. 204 AND 205. *Pliohippus* or *Hipparion*, sp.   Second and fourth metatarsals, lateral views, $\times$ ½.   Fig. 204, metatarsal IV, no. 21475; fig. 205, metatarsal 2, no. 21479.   Ricardo Pliocene, Mohave Desert, California.

Fig. 206. *Pliohippus?*, sp.   Distal end of metapodial, no. 22325, $\times$ ½.   Ricardo Pliocene, Mohave Desert, California.

Fig. 207. *Pliohippus* or *Hipparion*, sp.   Cuboid, no. 21198, inner view, $\times$ ½.   Ricardo Pliocene, Mohave Desert, California.

Figs. 208 AND 209. *Pliohippus* or *Hipparion*, sp.   Astragali, $\times$ ½.   Fig. 208, no. 21495; fig. 209, no. 21213.   Ricardo Pliocene, Mohave Desert, California.

Fig. 210. *Hipparion* or *Pliohippus*, sp.   Astragalus, no. 22326, $\times$ ½.   Ricardo Pliocene, Mohave Desert, California.

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[42] Weithofer, A., Beiträge zur Kenntniss der Fauna von Pikermi bei Athen, Beitr. Palae. Geol. Oest-Ung., Bd. 6, Taf. 13, figs. 14 and 15, 1888.

of the proximal face is more deeply indented than in metapodials of the European form, and there is a separation of the posterior region of the ectocuneiform facet as a distinct lunate articular area. In *Hipparion* the posterior area is not separated from the anterior.

The proximal face of metacarpal III in no. 21202 (fig. 194) seems to differ from that of *Hipparion* in possessing a small notch in the middle of the unciform facet. The dimensions are near those of the European form.

The slender proximal phalanx from Ricardo seems more slender than in *Hipparion* forms of the Old World and approaches the type of *Pliohippus*. In some cases, proximal phalanges of *Hipparion* may be heavier than the wider form from Ricardo seen in no. 21197 (fig. 196).

The nature of the lateral metapodials in the Ricardo specimens can be nearly duplicated in *Hipparion* of the Old World or in *Protohippus* or *Pliohippus* of America.

A cuboid, no. 21204, from the Ricardo differs from that of *Hipparion* as figured by Weithofer mainly in the separation of the posterior facets for navicular and ectocuneiform. In *Hipparion*, as shown by Weithofer, these facets are contiguous as in *Equus*. This specimen differs from the cuboid in the Barstow *Merychippus* forms in the position of the posterior facet for the navicular somewhat nearer the proximal end of the element, and in its slightly less prominent tuberosity.

<center>Oreodontidae</center>

<center>Merycochoerus? (Pronomotherium?) californicus, n. sp.</center>

Type specimen, no. 21351, a fragmentary skull with molar dentition, from locality 1755, Ricardo beds, Mohave Desert, California.

A large, highly specialized oreodont is represented by the type material and several other more imperfect specimens from the beds near Ricardo. So far as known this form is one of the largest and most highly specialized of the oreodonts. Its characters are near those of *Merycochoerus* and approach those of the bizarre *Pronomotherium* from the Madison Valley beds of Montana.

The skull is very badly crushed, but shows some of the general outlines. It seems short and the facial region appears depressed. The orbits are small. The zygomatic arch is deep below the

orbit, and is widely expanded.   The occipital region (fig. 211) is extremely wide as in *Merycochoerus*.   The widely spreading mastoid plates merge into the heavy paroccipital processes below.   The sagittal crest is low.   The palate is wide; the processes are relatively heavy and project relatively far inferiorly.

The premaxillaries are closely united with the maxillaries, and the superior margin of the premaxillaries slopes backward at a low angle indicating a low, wide anterior nasal opening.   The infraorbital foramen is situated over the anterior region of M^1.
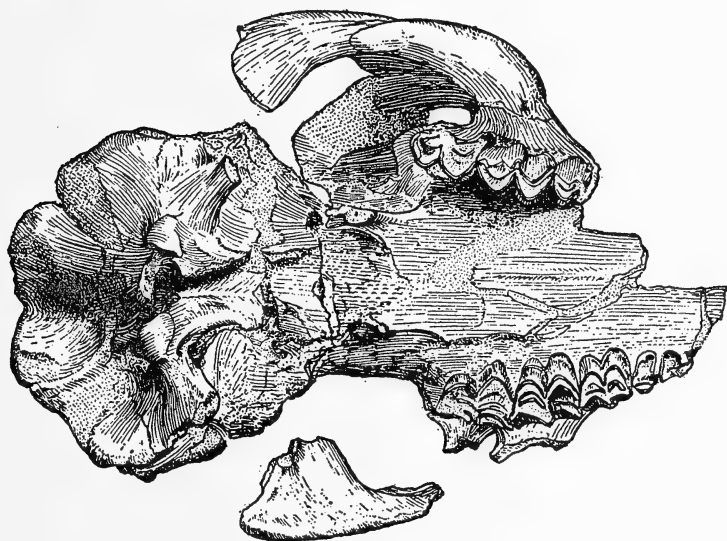
FIG. 211.   *Merycochoerus?* (*Pronomotherium?*) *californicus*, n. sp.   Skull, type specimen no. 21351, ventral view, $\times \frac{1}{4}$.   Ricardo Pliocene, Mohave Desert, California.

The cheek-teeth are large and seem to show a very advanced stage of development in relative length of the molar series, in hypsodonty, and in complication of the premolars.

The molars are large, the crowns are long, and the styles prominent.   The internal cingulum is faint on the type specimen, but is strongly marked on no. 21353 (fig. 214) from the Ricardo beds.   The molars do not differ greatly from those of *Merycochoerus buwaldi* of the Barstow beds excepting in their larger size.

The premolars of the type specimen are imperfect.   On a specimen (no. 23128) associated with the type the premolars are well preserved and have approximately the same dimensions as those
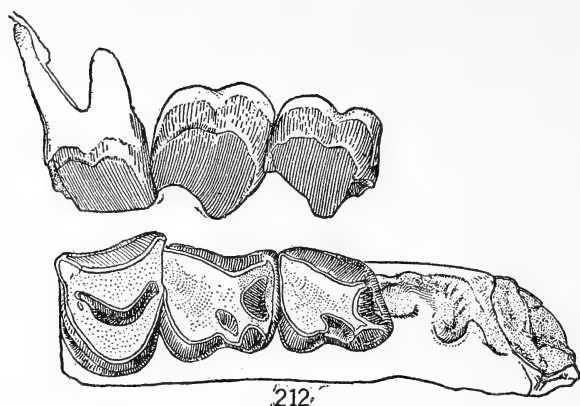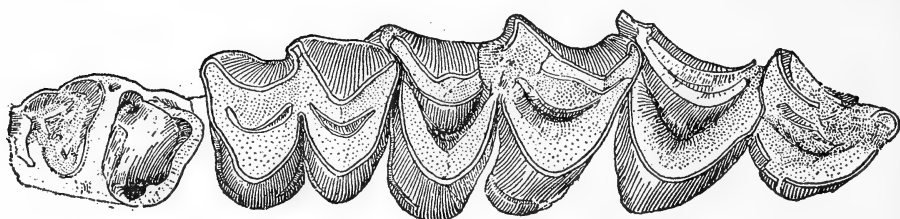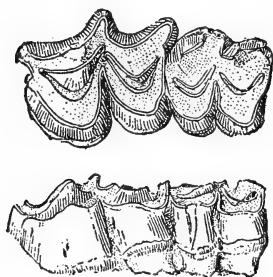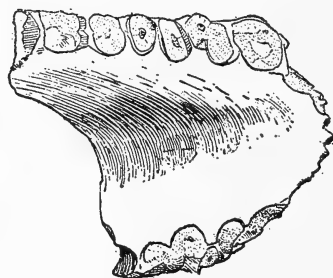
FIG. 212. *Merycochoerus? (Pronomotherium?) californicus?*, n. sp.   Upper premolars, no. 23128, $\times \frac{9}{10}$.   Ricardo Pliocene, Mohave Desert, California.

FIG. 213. *Merycochoerus? (Pronomotherium?) californicus*, n. sp.   Upper molars, occlusal view, $\times \frac{9}{10}$.   Type specimen, no. 21351.   Ricardo Pliocene, Mohave Desert, California.

FIG. 214. *Merycochoerus? (Pronomotherium?) californicus?*, n. sp. M^1 and M^2, no. 21353, $\times \frac{1}{2}$.   Ricardo Pliocene, Mohave Desert, California.

FIG. 215. *Merycochoerus? (Pronomotherium?) californicus?*, n. sp.   Symphysis of mandible, no. 21567, $\times \frac{1}{2}$.   Ricardo Pliocene, Mohave Desert, California.

imperfectly represented on the type specimen. It is presumed that no. 23128 represents the same form as the type though this cannot be proved with the material available.

All of the premolars in no. 23128 show external and internal cingula. They are at least as hypsodont as in *Merycochoerus proprius*, and were probably longer than in that form. In the state of wear shown in the material available it is not evident that the premolars were more hypsodont than in *M. buwaldi* of the Barstow. The external faces are flatter than in *M. proprius*, but do not show the suggestion of median longitudinal ribs seen in *M. buwaldi*. P⁴ shows approximately the form seen in *M. buwaldi*. P³ seems slightly more advanced, and P² is decidedly more progressive than in *M. proprius* or *M. buwaldi*. In P² the diameter of the crown is greater transversely and the anterior pocket is much larger.

The upper canine is possibly a little smaller than in *M. proprius* compared with the size of the skull. It is somewhat larger relative to the size of the skull than in *Pronomotherium altiramum*.

MEASUREMENTS OF SKULL, No. 21351

Width across occipital region including expansion of mastoid plates....	175	mm.
Height of inion above upper border of foramen magnum...........	a92	
Width of palate between inner borders of M²....................	74	
Width of posterior narial opening between processes..............	49	
Height of zygomatic arch immediately below orbit................	45	

a, approximate.

MEASUREMENTS OF DENTITION

Length of upper molar-premolar series, no. 21351 and no. 23128 combined..	167.5 mm.
Length of premolar series, no. 23128...........................	63.5
Length of molar series, no. 21351..............................	a104

	No. 23128
Anteroposterior diameter of superior canine at base...............	14.3
P², anteroposterior diameter...................................	16.5
P², greatest transverse diameter...............................	13.5
P³, anteroposterior diameter..................................	16
P³, transverse diameter.......................................	17.2
P⁴, anteroposterior diameter..................................	16
P⁴, transverse diameter.......................................	21.1

	No. 21351
M¹, anteroposterior diameter..................................	28.3
M¹, transverse diameter.......................................	25.2
M², anteroposterior diameter..................................	36.8
M², transverse diameter.......................................	a31.3
M³, anteroposterior diameter..................................	45.5
M³, transverse diameter.......................................	a28.5

a, approximate.

MEASUREMENTS OF No. 21353, AN INDIVIDUAL WITH WELL WORN TEETH, AND
M³ WELL WORN

M^2, anteroposterior diameter.................................... a27 mm.
M^2, transverse diameter... a28
M^3, anteroposterior diameter.................................... 41.2
M^3, transverse diameter.. 33.2

   a, approximate.

The dentition of the Ricardo oreodont shows an unusually long molar series and relatively great length of this series compared with the premolars. The length of the premolar series seems to be about 61% that of the molars, while in a *Merycochoerus* specimen available for comparison the length is greater. In Leidy's type of *M. proprius*, it is 85%. In the *Pronomotherium* specimens described by Douglass, the length is 70% for *P. laticeps*, and 77% for *P. altiramum*. In *M. buwaldi* from the Barstow beds the corresponding percentage is 71.3%.

The whole assemblage of characters in the Ricardo specimen seems to distinguish it as a member of the *Merycochoerus* group, and one of the most advanced forms in the group.

COMPARATIVE MEASUREMENTS OF UPPER MOLAR AND PREMOLAR SERIES

	Length of premolar series	Length of molar series
Merycochoerus proprius, type............................	68 mm.	80
Merycochoerus buwaldi...................................	53.5	75
Merycochoerus? californicus*...........................	63.5	104
Pronomotherium laticeps.................................	56	80
Pronomotherium altiramum...............................	70	90

* In *M.? californicus* the molar and premolar dentition are not completely represented in one specimen.

Compared with *Pronomotherium altiramum* the Ricardo form seems to have at least as progressive teeth, but the canine is smaller. The final test of relationship will depend on appearance of good skull material for comparison.
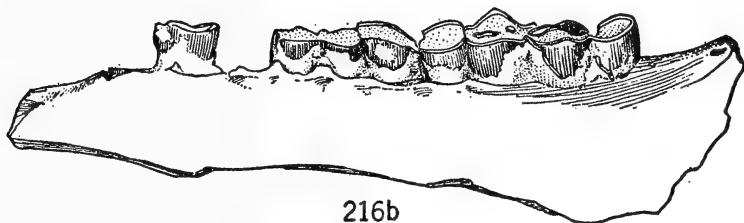
CAMELIDAE

The camel remains from the Ricardo beds consist almost exclusively of limb bones. Only a few jaw fragments are known, of which a mandible with several molar teeth (no. 22516, figs. 216a, 216b) is the most important specimen.
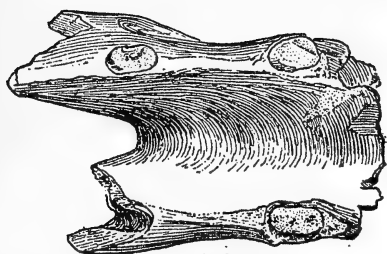
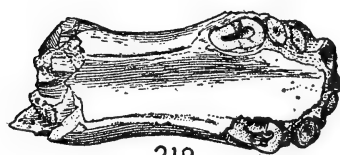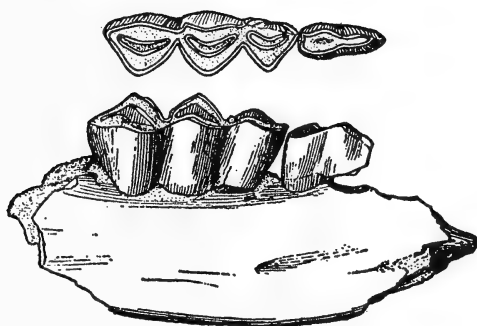At least two camel types are represented in jaw fragments found

Figs. 216a and 216b. *Procamelus?* or *Alticamelus?*, sp. Mandible, no. 22516, $\times \frac{1}{2}$.
Fig. 216a, dorsal view; fig. 216b, lateral view. Ricardo Pliocene, Mohave Desert, California.

Fig. 217. *Pliauchenia?* or *Alticamelus?* sp. Symphysis of mandible, no. 23115, $\times \frac{1}{2}$.
Ricardo Pliocene, Mohave Desert, California.

Fig. 218. *Procamelus?*, sp. Symphysis of mandible, no. 21305, dorsal view, $\times \frac{1}{2}$. Ricardo Pliocene, Mohave Desert, California.

Fig. 219. *Procamelus?*, sp. Dm$_3$ and Dm$_4$, no. 21504, natural size. Ricardo Pliocene, Mohave Desert, California.

at Ricardo. One, a small form represented by fig. 218, presumably belonging to the genus *Procamelus*; a larger form, fig. 217, is possibly *Alticamelus*.

The mandible no. 22516 with dentition shows three premolars of which the anterior tooth is small, but two-rooted. This tooth is moderately hypsodont. This specimen evidently represents *Procamelus* or *Alticamelus*.

A small specimen, no. 21504 (fig. 219), shows the milk dentition. Dm_4 is long and narrow and the anterior lobe is well displayed.

Among the foot bones there are at least four types represented. No. 22521 (fig. 231) belongs to a very large form with relatively wide astragalus. This form is presumably *Pliauchenia*. No. 23113 (fig. 229) with a large but narrow astragalus is apparently *Alticamelus*. No. 22519 (fig. 230) may represent *Alticamelus*. No. 22518 (fig. 232) and no. 22520 (fig. 233) are presumably forms of *Procamelus*.

BOVIDAE

MERYCODUS, near NECATUS Leidy

A considerable number of parts of jaws, horns, and limb elements representing a *Merycodus* species near the Barstow form referred to *M. necatus* have been found at Ricardo. Horns and antlers found in the lower portion of this section are not materially different from those of the Barstow species determined as *M. necatus*, as is seen in no. 22448 (fig. 235). In no. 22449 (fig. 234) the horn has a longer, more slender shaft or beam. In the Barstow fauna forms with the longer beam grade into those with the shorter, flatter beam of the *M. necatus* type.

The jaws and teeth of the Ricardo specimens (figs. 236–245) do not differ greatly from those referred to *Merycodus necatus* in the Barstow fauna, and evidently represent a species near that form.

In the Ricardo form the lower molars seem in some cases slightly narrower. In M_3 the posterior lobe may be large showing in some cases an incipient division on the outer side (fig. 242), or it may be relatively small and simple (fig. 241). Some of the specimens with the largest lobes are found low down in the section and below the basalt, while specimens with relatively small lobes are known above the basalt. The premolars may be considerably compressed laterally (fig. 240). The characters mentioned may warrant

specific separation from the Barstow species when the form is better known.

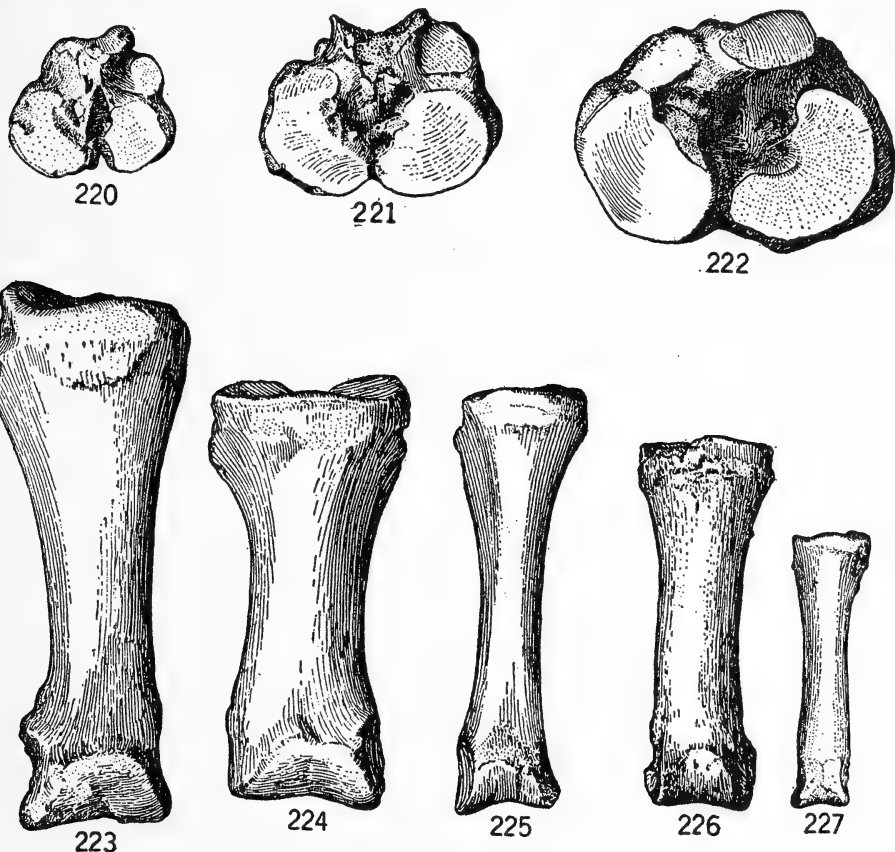In the milk dentition Dm$_4$ (fig. 239) has a large anterior lobe.

FIG. 220. *Procamelus?*, sp. Proximal facets of cannon bone of posterior limb, no. 23117, × ½. Ricardo Pliocene, Mohave Desert, California.

FIG. 221. *Alticamelus* or *Pliauchenia?*. Proximal facets of cannon bone of posterior limb, no. 23116, × ½. Ricardo Pliocene, Mohave Desert, California.

FIG. 222. *Pliauchenia* or *Alticamelus?* Proximal facets of cannon bone of posterior limb, no. 23118, × ½. Ricardo Pliocene, Mohave Desert, California.

FIGS. 223 TO 227. First phalanges, × ½. Fig. 223, *Alticamelus?*, sp., no. 21563; fig. 224, *Pliauchenia?*, sp., no. 21564; figs. 225 and 226, *Alticamelus* or *Procamelus*, sp., no. 23119 and no. 23114; fig. 227, *Procamelus*, sp., no. 22517. Ricardo Pliocene, Mohave Desert, California.

A number of limb elements (figs. 246–252) of *Merycodus* found in the Ricardo have not as yet shown characters distinguishing them clearly from the Barstow form.

The Ricardo form of *Merycodus* in some respect approaches *Capro-meryx* of the Pleistocene a little more closely than the Barstow
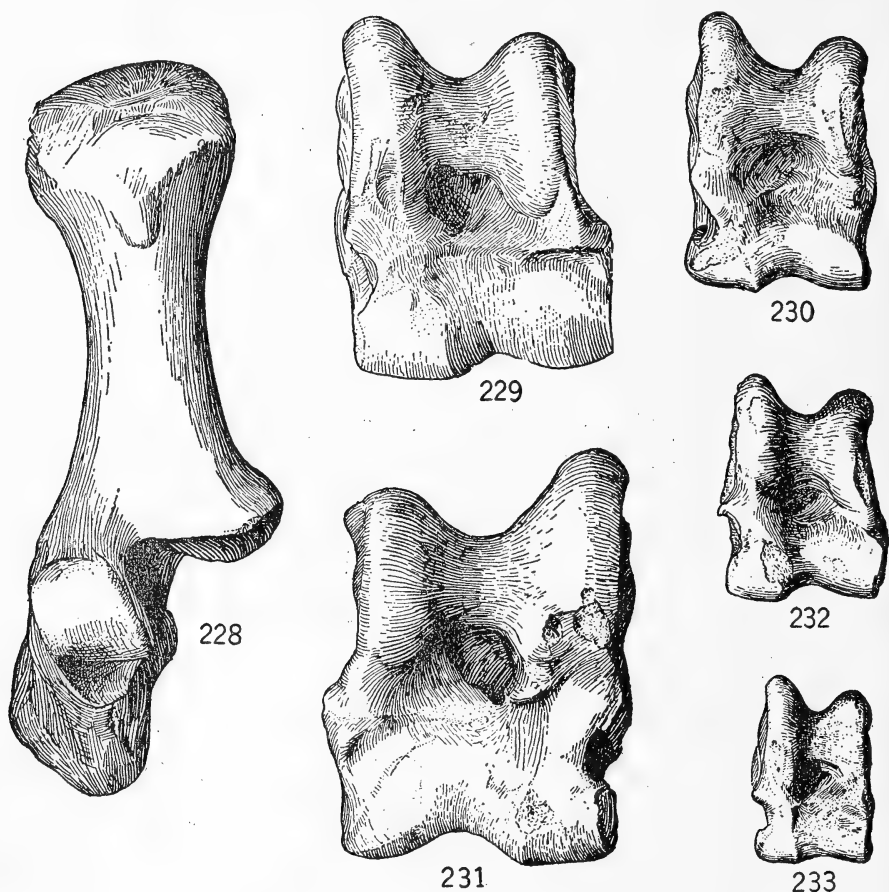

FIG. 228. *Alticamelus?* or *Pliauchenia?*, sp. Calcaneum, no. 21567, × ½. Ricardo Plio-cene, Mohave Desert, California.

FIG. 229. *Alticamelus?*, sp. Astragalus, no. 23113, × ½. Ricardo Pliocene, Mohave Desert, California.

FIG. 230. *Alticamelus?*, sp. Astragalus, no. 22519, × ½. Ricardo Pliocene, Mohave Des-ert, California.

FIG. 231. *Pliauchenia?*, sp. Astragalus, no. 22521, × ½. Ricardo Pliocene, Mohave Desert, California.

FIGS. 232 AND 233. *Procamelus?*, sp. Astragali, × ½. Fig. 232, no. 22518; fig. 233, no. 22520. Ricardo Pliocene, Mohave Desert, California.

species. The tendency to grooving or division of the third lobe of M_3 is a progressive character. The degree of hypsodonty of the
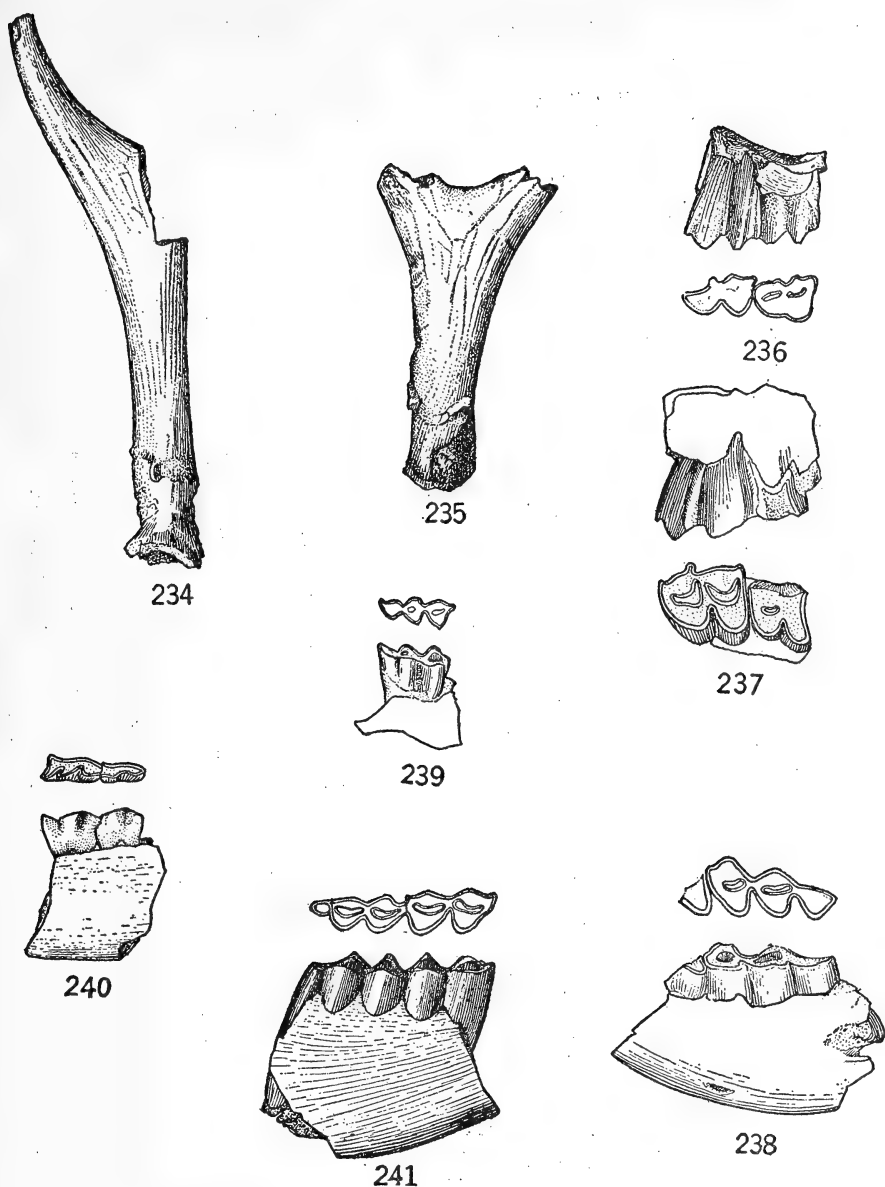
FIGS. 234 TO 241 represent specimens from the Ricardo Pliocene, Mohave Desert, California.

FIGS. 234 AND 235. *Merycodus,* near *necatus* Leidy. Antlers, $\times \frac{1}{2}$. Fig. 234, no. 22449; fig. 235, no. 23448.
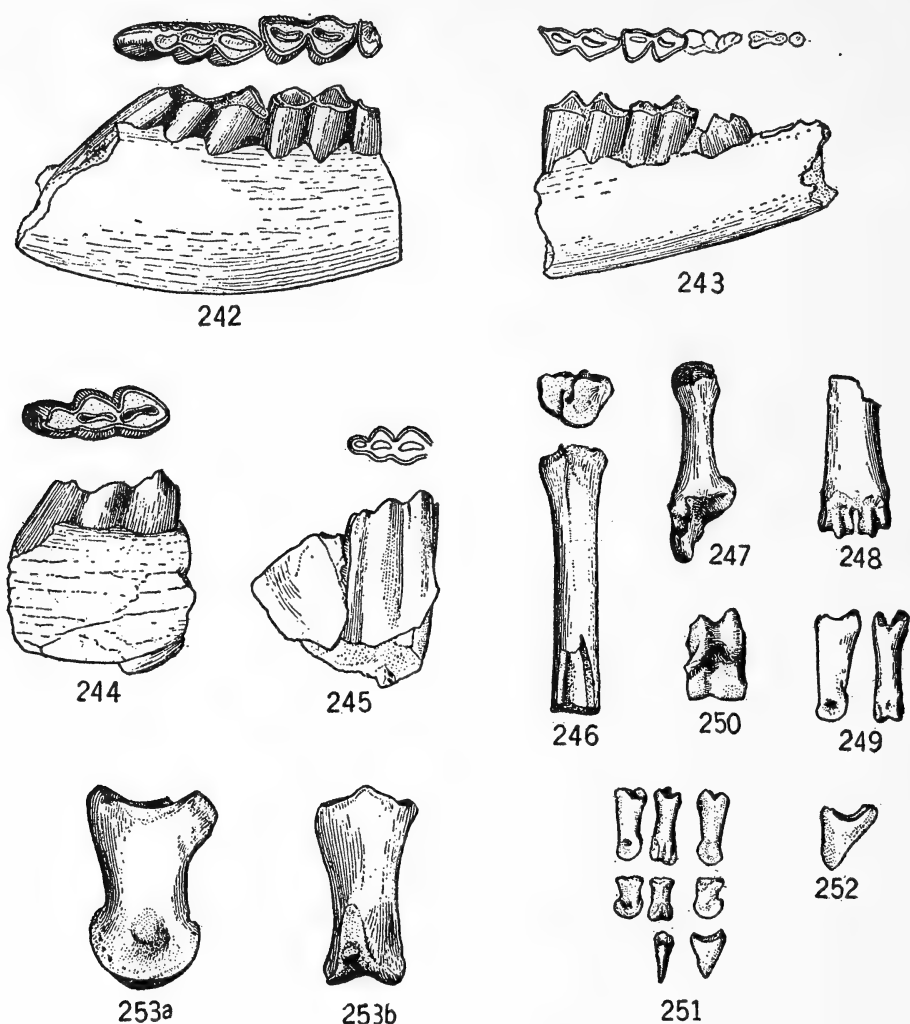
FIGS. 236 AND 237. *Merycodus,* near *necatus* Leidy. Superior molars, natural size. Fig. 236, no. 22452; fig. 237, no. 22455.

FIG. 238. *Merycodus,* near *necatus* Leidy. M_3 no. 22327, natural size.

FIG. 239. *Merycodus,* near *necatus* Leidy. Dm_4, no. 22453, natural size.

FIG. 240. *Merycodus,* near *necatus* Leidy. P_2 and P_3, no. 22456, natural size.

FIG. 241. *Merycodus,* near *necatus* Leidy. M_2 and M_3, no. 22454, natural size.

1267

FIGS. 242 TO 245. *Merycodus*, near *necatus* Leidy. Inferior dentition, natural size. Fig. 242, M₂ and M₃, no. 21322; fig. 243, P₄, M₁, and M₂, no. 22450; fig. 244, M₃, no. 22457; fig. 245, M₃, no. 22451. Ricardo Pliocene, Mohave Desert, California.

FIGS. 246 TO 252. *Merycodus*, near *necatus* Leidy. Limb elements, $\times \frac{1}{2}$. Fig. 246, anterior cannon bone, no. 22515; fig. 247, calcaneum, no. 21321; fig. 248, distal end of cannon bone, no. 22513; fig. 249, first phalanx, no. 22513; fig. 250, astragalus, no. 22514; fig. 251, phalanges, no. 22512; fig. 252, ungual phalanx, no. 22512. Ricardo Pliocene, Mohave Desert, California.

FIGS. 253*a* AND 253*b*. Bovid or cervid, indet. Second phalanx, no. 22458, natural size. Fig. 253*a*, lateral view; fig. 253*b*, dorsal view. From beds referred to the Ricardo Pliocene, locality 2578, two miles south of Warren, a station on the Southern Pacific Railroad at eastern end of Tehachapi Pass, Mohave Desert, California.

Ricardo species is still much less than in *Capromeryx*, but the difference separating the two is not more than would be expected in an ancestor of *Capromeryx* as far removed in time as the Ricardo species is removed from that of Rancho La Brea.

BOVID OR CERVID, INDET.

A single second phalanx (no. 22458, figs. 253*a*, 253*b*) from locality 2578, two miles south of Warren on the Southern Pacific Railroad at the eastern foot of the Tehachapi Pass represents an antelope or deer differing both from *Dromomeryx* and from the antelopes of the Thousand Creek fauna. It is much larger than *Merycodus*, smaller than *Dromomeryx*, and approaches the Thousand Creek forms in size. The articulation surfaces differ somewhat from those of the Thousand Creek forms. It is hoped that more material may be secured from this locality.

Transmitted April 1915

EXTINCT FAUNAS OF THE MOHAVE DESERT, THEIR SIGNIFICANCE IN A STUDY OF THE ORIGIN AND EVOLUTION OF LIFE IN AMERICA

INTRODUCTION

IT IS almost a rule that features of the natural world which have exerted an unusual influence in developing our emotional, poetic and religious natures, when brought within the range of scientific inquiry seem only more deeply to excite our wonder and respect. Thus, it has happened that the deserts of the world, having furnished the stimulus for some of our earliest poetic and religious literature, appear to the scientist of to-day as places in which nature meets us with unusual frankness, and where her wonders almost clamor to be understood.

In those fields of history covering the development or evolution of the external form of the earth and of the life upon it, deserts have been very significant sources of information, and the so-called badland formations in the arid or semi-arid regions of western North America have been recognized as playing a very important part. As the widespread exposures of these formations have elsewhere in America proved veritable museums of wonderfully preserved remains, it has seemed worthy of remark that the extensive badlands in the Great Basin region of America have with few exceptions furnished almost nothing bearing on the history of life. The early geologic explorers in Nevada and California found little bearing on the paleontologic story of the area they examined. Later investigators in the bad-lands of these regions have generally failed to report determinable vertebrate remains, and the life record has until recently remained practically a closed book. It has been with much interest, therefore, that those concerned with the history of western North America, and with its bearing on the whole story of life growth or evolution, have seen coming to light with the past decade chapter after chapter of this missing record.

With the exception of the John Day region of eastern Oregon, which supplies an important geologic and paleontologic record, the largest part of our knowledge of the history of mammalian life west of the Wasatch is obtained in the heretofore unexplored deposits of the Mohave Desert. At the present time there are available from the Mohave at least three extinct mammalian faunas previously unknown, or only imperfectly known, in the Great Basin. The life record given us by these faunas, the evolutionary series to which they contribute, and the suggestions which they offer concerning the origin, evolution and world relationships of life in America, furnish very significant chapters in the history of the western side of the continent.

Nearly twenty years ago several very fragmentary specimens from the Mohave were forwarded to the writer by Dr. Stephen Bowers, the material having been obtained in part by John T. Reed. The earliest material from definitely known localities coming to the writer was received in the spring of 1911 from John R. Suman, then a student at the University of California. The collection consisted of a small quantity of loose bones and teeth obtained on the desert by H. S. Mourning. These specimens furnished the basis for the first study of the Upper Miocene fauna of the Mohave. In the following year C. L. Baker, a fellow in paleontology at the University of California, visited the localities reported by Mr. Mourning and secured a fine collection of mammal material from the Miocene near Barstow, and a small amount of material from the Pliocene at Ricardo. Other important collections were made later by Mr. Baker, Mr. Mourning, Mr. J. P. Buwalda and by many students in paleontology from the University of California. Following his work on the Mohave in 1913, Mr. Buwalda independently visited a locality in the eastern portion of this region, and obtained a most interesting collection of Pleistocene remains in a formation to which he has given the name Manix beds. This material gave us for the first time a representative group of vertebrates from the Pleistocene of the Great Basin.

The collections brought together at various times have opened to us a view of the mammalian life of the Mohave Desert in three periods: the Barstow fauna of Upper Miocene age, the Ricardo fauna of early Pliocene stage and the Manix fauna from the Pleistocene.

Outline map showing relation of the Mohave Area to other Pacific Coast and Great Basin regions during the later geological periods. Within the Mohave region the principal faunal localities are indicated as follows: *B*, Barstow fauna; *R*, Ricardo fauna; *M*, Manix fauna.

The Mohave Desert of To-Day

The Mohave Desert area of California has been generally recognized as one of the least attractive portions of the southwest. It has been described as a forbidding land of heat and thirst. The deception of its mirages is a current example of the lure of unreality, and its great stretches of sand and dust have appeared to function mainly as barriers to human progress. The history of exploration has seemed amply to justify current views concerning the desert, as year after year prospectors or explorers, deceived by distances or miscalculating the position of scattered water sources, have paid with their lives the penalty for inaccurate judgment.

In spite of seeming obstacles offered to one who would make its acquaintance, those who have come to know the Mohave seem always to cultivate the friendship. The prospector has cheerfully risked his life, not alone for the desire of gain, but because the fascination of the desert always increases. The traveler is inevitably deeply influenced by the uncertain magnitude of distance, by the silence, and the unusual forms and brilliance of the landscape by day and night. Once an acquaintance is formed, distrust and fear are replaced by reverence of the quiet strength of nature exhibited here in factors which are too large or too elusive to be fully comprehended.

The Mohave lies in the middle of the southern half of the state of California, the desert proper being situated in the angle where the Sierras turn west to meet the Coast Ranges. The western limits of the area are sharply marked by the abruptly rising wall of the bordering mountain ranges. The limits to the east are not so clearly marked, being considered by some to reach the eastern border of the state; by others they are held to extend less than half the distance to the Colorado River.

The elevation of the desert floor ranges from 2,000 ft. approximately to 4,000 ft. above the sea, in sharp contrast to the basin of the Salton Sea, which extends below the level of the ocean a short distance to the south. The topography of the region is characterized by great stretches of open plains many miles in extent, over which scattered mountain peaks or ranges are distributed with little suggestion of order in their arrangement.

The total rainfall of the desert amounts only to a few inches per year. Living streams are rare, and travel in all of this region is necessarily limited by accessibility of the few localities at which

potable water can be obtained.   Rain falls largely in the middle of
the winter season, and throughout the greater part of the year there
is no precipitation.   The water at times comes with a rush, flows
off rapidly as floods, and sometimes causes considerable damage to
artificial obstacles in the path of the current.   With the exception
of the Mohave River, which runs a thin superficial stream for a
considerable portion of the year, there are very few points at which a
supply of water can be obtained on the surface.   Investigation has
shown that artesian water is available over certain areas, and agri-
culturists have operated to some extent by irrigation with water
obtained from wells.

The diminished rainfall, the unhindered influence of a brilliant
sun and the moderate altitude have given to the Mohave a dis-
tinctly arid climate; and with the climate go all of the accompanying
characteristics of life, of erosion and deposition, and of the peculiar
land forms of an arid country.

The vegetation of the Mohave area is at the present time limited
mainly to desert types, the contrast with the flora beyond the ridge
immediately to the west being very marked.   In crossing the
Tehachapi Range from the Great Valley of California to the Mohave
one finds the valleys of the western side thickly studded with oak,
sycamore, and willow, and the hills are carpeted with grass.   On the
eastern slope the whole aspect of the vegetation changes suddenly,
as if one were entering a foreign land.   The yuccas and the creosote
bush replace oak and grass, and the oddly outstretched arms of the
Joshua trees seem everywhere raised up as if to attract attention.
Plants of arboreal type are rare, and, excepting a few junipers, the
yuccas furnish the only trees.   Creosote bushes are generally
present, but are sometimes sparingly represented.   Perhaps to show
that under adverse conditions nature means only to be just and not
unkind, the spring and early summer find the desert dotted here and
there with patches of flowers of unusual beauty and fragrance, offer-
ing their charms as an antidote for the misery of thirst about them.

The living mammalian fauna of the Mohave comprises thirty-five
species, of which twenty-one are rodents.   The Ungulata are repre-
sented only by the pronghorn antelope and the desert bighorn.
The Carnivora include the desert coyote, the Mohave Desert kit
fox, the California raccoon, a spotted skunk, a striped skunk, the
northwest cougar, and the desert wildcat.   The rodent fauna in-
cludes thirteen genera.   The species are mainly characteristic
desert forms.   Of the living mammals only a few genera are known

also in the older faunas of the Mohave.   Some of the existing types, as the bighorn, are immigrants from the Old World, and arrived very late in the history of this region.   Others, as the pronghorn, are evidently of American origin.

Geologic Occurrence and Age of the Mohave Fossil Beds

The Miocene and Pliocene faunas in the Mohave area occur in an accumulation of strata amounting to not less than 7,000 to 8,000 ft. in thickness.   The beds consist in large part of volcanic materials which are interstratified with clay strata, shales, and desert conglomerates.   The origin of the immense quantities of ashes piled up in these formations is as yet unknown.   They were probably derived from volcanoes and other channels for extrusion of lavas and ash in or near the Mohave area.   In a few strata abundant remains of fresh-water mollusks indicate deposition of these beds in fresh-water ponds or lakes.   At other levels the skeletons of large desert tortoises and numerous remains of land mammals now characteristic of flat open country suggest accumulation upon dry land.

Mr. Baker considered that the Miocene and Pliocene deposits of the Mohave were formed mainly under physical conditions similar to those operating in the desert at the present time.   As nearly as the writer can judge, the climate conditions in the Mohave area through the period in which the mammal beds were being laid down, were those of a semi-arid region somewhat more humid than the Mohave of to-day, and the climate corresponded approximately to that now obtaining in the southern end of the Great Valley of California.

Sections of the older formations containing fossils in the Mohave area are most satisfactorily shown in great thicknesses of strata exposed in the hills north of the town of Barstow, and in excellent exposures at Ricardo between the eastern foot of the Sierras and the El Paso Range.   At both localities exposures extending for many miles give unusual opportunity to examine the structure of the formations, and bring to view the strata containing mammalian remains.   As shown in the accompanying photographs, the formations at these localities are sculptured by erosion into most fantastic shapes, like those of the famous bad-land forms of the western Great Plains region.   In the intricate gullies and caverns of these exposures there is found a most fascinating field, in which to hunt for the big game of the Mohave of ancient times.

The oldest fossil-bearing beds of the Mohave area rest upon a

basement consisting in part of granite and metamorphosed or altered rocks of pre-Tertiary age. They may also rest upon extruded igneous rocks, presumably at least as old as Lower Miocene.

The oldest known strata containing vertebrate fossils in the Mohave area are found in the Upper Miocene near Barstow. Leaves stated to be of Eocene age were collected by H. W. Fairbanks at Black Mountain in the El Paso Range on the western border of the desert, but no additional material representing this stage has as yet been found.

To the whole series of older or Tertiary sediments of the Mohave area, O. H. Hershey has given the name Rosamond series. Mr. Baker has shown that the series is divisible into a number of quite distinct divisions. Some of these may represent quite widely separated periods. Evidence which the writer obtains from a study of the faunas indicates that the deposits north of Barstow containing a Miocene fauna may represent a formation quite distinct from that at Ricardo containing a Pliocene fauna. The term Barstow formation is used for the beds containing the Upper Miocene fauna. The lower portion of the Barstow section may be considerably older than Upper Miocene and may constitute a distinct formation. The name Ricardo formation is used for the strata with a Pliocene fauna at Ricardo.

The youngest fossil beds of the Mohave region appear in a small basin about 20 to 40 miles east of Barstow. The deposits cover an area about 25 miles in length and represent accumulation in a small body of fresh water, to which Mr. Buwalda has given the name Manix Lake. The deposits consist of clays and sands aggregating about 75 feet in thickness. Their accumulation was initiated by the raising of a barrier across the Mohave River drainage, causing the ponding of the river which formed Manix Lake. The lake disappeared and deposition ceased when the river cut through the barrier across its path.

Remains of extinct vertebrates are found over a wide area in the deposits of the Mohave region. They are not abundant in many places, and one may search long for even a fragment of a bone or tooth. In a few localities fragmentary specimens were found scattered over the ground in considerable numbers, but connected parts of skeletons are rare. At several points where bones were found well exposed, and in their original position in the rock, they seemed to be scattered and disconnected, showing that the parts of skeletons were generally widely separated and broken or weathered

before final burial. The process of entombment was probably similar to that in operation on the desert at the present time, where bones of horses and cattle are pulled apart by coyotes, scattered by rain-wash, and in a large measure rotted away before any portion of the animal is permanently covered over.

The collections obtained include several thousand specimens, mostly teeth and portions of limb-bones. In a few cases, good jaws and parts of skulls were secured, but unlike the occurrence in many of the formations in the west, these beds seem almost never to contain complete skeletons.

In the Miocene beds of Barstow vertebrate remains are found almost exclusively in the uppermost zone. In the Ricardo Pliocene fossil remains were found in several parts of the section, but the best representation of the fauna appears near the middle and toward the top of the formation.

Although only a few localities have been found at which even small collections of mammalian bones can be obtained in the area of the Mohave region examined, it is evident that deposits representing the formations in which bones occur are very widely spread over this area, and future exploration may be expected to add greatly to the information now available.

The formations containing mammalian faunas in the Mohave area, and their approximate relations to the recognized geological scale are as follows:

Geological Periods		Mammal Beds of the Mohave Area	Recognized Formations of other Western Areas
Pleistocene		Manix Beds	Rancho La Brea, California
Pliocene	Upper		
	Middle		
	Lower	Ricardo Beds	Thousand Creek, Nevada Rattlesnake, Oregon
Miocene	Upper	Barstow Beds	Cedar Mountain, Nevada
	Middle		Mascall, Ore., and Virginia Valley, Nev.
	Lower		Columbia Lava of Oregon

The Oldest Known Mammal Fauna of the Mohave, the Upper Miocene of Barstow

The fauna of the oldest mammal-bearing beds of the Mohave area includes about thirty species, many of which are known only by fragmentary material. The larger part of the collection consists of the remains of horses and camels. The bones of horses, accompanied by those of other animals, are sufficiently abundant at one horizon to mark a zone or layer which can be traced for a number of miles, and is known as the Merychippus zone, from the most common fossil, a little three-toed horse of the genus *Merychippus*.

Of the horse there are at least four species represented. *Merychippus* is the most abundant form and includes two or three types. They were mainly animals about as large as small colts of the modern horse. They possessed one large middle toe and two small, scarcely-functional side toes on each foot. Their heads were long and had peculiar depressions on the sides of the face. The back-teeth were long, and as they were worn off from the top, they grew up from the root, as in the modern horse. These animals were of a distinctly open country or plains type, and evidently supported themselves by grazing or grass-feeding, rather than by browsing from brush as do the deer. One of the larger species of *Merychippus* is almost indistinguishable from the genus *Protohippus*, the next or later stage in the evolutionary series of the horse. An exceedingly rare form related to *Merychippus* is represented by a few large teeth which may possibly belong to a representative of the genus *Pliohippus*, a larger animal somewhat like the modern horse. One of the most common *Merychippus* species is a small form approaching in its characters the genus *Hipparion*, the characteristic horse of the following Ricardo or early Pliocene epoch. The Ricardo Hipparions are possibly descendants of this small Barstow horse.

Two rare horses found in the Barstow fauna, like the earliest forms of the horse group, have back-teeth with short crowns not adapted for grazing. One belonging in the genus *Hypohippus* was a large three-toed animal, in which the side toes are much larger than in *Merychippus*. The teeth are those of a browsing, not of a grazing animal. The feeding habits of this horse must have differed very considerably from those of *Merychippus*, and it probably occupied a somewhat different range. The other rare form represents a species of *Parahippus*, also of a browsing rather than of a grazing type. It

may be repeated that *Hypohippus*, *Parahippus* and *Protohippus* are collectively known only by a very small number of specimens. The grazing *Merychippus* is the common and characteristic animal of the fauna.

Associated with the horses are rare remains of a primitive wild pig or peccary. There is also a rare oreodon, one of the late representatives of a large family, which is perhaps the most characteristic American mammal group in the whole history of our fauna. It included creatures resembling on the one hand the pigs and on the other hand the camels and deer. There are also rare remains of a large antelope or deer of the genus *Dromomeryx*. A small deer-antelope, *Merycodus*, a dainty creature with teeth like an antelope and horns like a deer, is represented at several localities by abundant fragments of teeth, limb-bones and antlers. A large four-tusked mastodon is known by numerous fragments and occasional complete bones or large pieces of tusk.

Next to the horses the most numerous of the hoofed animals are the camels. They are known by at least three types. One is a small form of the genus *Procamelus*. A second and very large type probably belongs to the genus *Pliauchenia*. A third form with very large long limbs, a larger animal than the living camel, is possibly to be referred to the genus *Alticamelus*. Other genera may be present in the collection.

Of the remaining fauna, the rodents are represented by rabbits. The carnivores are known by at least eight species, including three large cats, at least one of which is a sabre-tooth with the greatly developed upper canine teeth. Two others may belong to the true cats, represented by the modern puma and wild cat, without the saber-like upper teeth. The dogs include one small form similar to the fox. A second type, *Tephrocyon*, one of the most characteristic animals of this horizon, is a form considered by many to be possibly the ancestor of the modern dogs and wolves. The most abundant creatures of the dog group are found in one or two representatives of the genus *Aelurodon*, very large, very heavy-jawed animals, much larger than any modern wolves, and even greatly exceeding the extinct dire wolf, now so well known by abundant skeletons from the asphalt deposits of Rancho La Brea. These animals were evidently not rare. They probably lived off the herds of large ungulates, sometimes bringing down a live animal, sometimes robbing the smaller wolves and the big cats of their prey.

Their unusually massive jaws and teeth seem built to serve as bone crushers, and there can be little doubt that the general state of dismemberment and destruction of all skeletons, and the absence of satisfactory paleontologic materials in the Barstow formation, is due in large part to the destruction of these scavengers.

Birds are known in the Upper Miocene beds by a few fragments representing an owl. Reptiles are represented by numerous fragments, and several nearly perfect skeletons of a large tortoise resembling in many respects the living desert tortoises of the Mohave.

The fauna of the Upper Miocene is as a whole that of an open country affording fairly abundant grass and herbage, and evidently better watered than the Mohave Desert of the present day. The numerous remains of grazing horses of the *Merychippus* type, the presence of mastodons, oreodons, of many deer-antelope, a considerable variety of camels, and a wild pig all indicate that grass and other nutritious vegetation must have been more abundant than at present. The relatively small representation of oreodons, and of browsing horses like *Hypohippus*, and the presence of large tortoises are possibly to be correlated with open semi-arid character of the country.

That small bodies of water were present at times in this area is shown by the presence of many fresh-water molluscan remains at certain horizons.

The fauna of the Barstow beds represents a stage in the evolution of Tertiary mammalian faunas previously not distinctly recognized in the Great Basin Province. It seems clearly later than the Middle Miocene life stage well known in the Mascall beds of Oregon and in the Virgin Valley beds of northern Nevada. The fauna is markedly older than the Rattlesnake Pliocene of Oregon and the Thousand Creek Pliocene of Nevada, representing the next described stages following the Middle Miocene in the Great Basin. The fauna of the Barstow beds has few if any species in common with that of the Ricardo formation, and is of a distinctly older type. Its nearest relationships are with the fauna of the Cedar Mountain region of southwestern Nevada, from which it possibly differs somewhat in stage.

The Second Fauna, the Ricardo Pliocene

The number of species represented in the Ricardo fauna is approximately equal to that found in the Barstow Miocene and the groups

of animals represented are in general of the same type.   Comparisons between these two faunas or life stages can therefore be made with some degree of satisfaction.   Coupled with the fact that the Mohave and Ricardo faunas comprise an approximately equal representation of similar groups, it is a matter of interest to note the almost complete difference between the species represented in the two, and that with one or two possible exceptions the species of the Ricardo stage represent more specialized or more progressive stages of evolution than the corresponding types seen in the Barstow fauna.

As in the Mohave stage, we find the Ricardo collections consisting mainly of horses and camels, the horses furnishing the most important and most characteristic forms thus far known.

The Ricardo horses are of at least three types, of which the most common includes one or more species of the genus *Hipparion*.   These are large, three-toed forms with the side-toes reduced and the grinding teeth large.   They resemble to some extent one of the small species of the Barstow Miocene, but are much larger; the side-toes are more reduced; and the teeth are longer-crowned, heavier, and of more complicated structure.   The Ricardo *Hipparion* differs from most of the species referred to this genus in America, and belongs to the true *Hipparion* type, which J. W. Gidley considers as characteristic of the Old World, in contrast to a New World form, *Neohipparion*.   Many of the teeth of the Ricardo species are practically indistinguishable from these of *Hipparion richthofeni*, a species abundantly represented in the early Pliocene or late Miocene of China.   It has generally been assumed that the Old World horses of the *Hipparion* type are descended from North American stock.   No types from which *Hipparion* might presumably be immediately derived by evolution are known in the Old World formations of the period just anterior to that in which *Hipparion* first appears, whereas in North America stages of evolution leading toward *Hipparion* are found in formations representing the period preceding the birth of this genus.   So far as the writer's observations have been carried, an evolutionary sequence leading to the genus, *Hipparion* is nowhere more clearly suggested than in the relation of the *Hipparion* of Ricardo to the Hipparion-like *Merychippus* of the Barstow Miocene.   It seems not improbable that the Old World *Hipparion* is derived from a West-American form near the Barstow *Merychippus*.

Living in the same region with the *Hipparion* in Ricardo time were at least two other types of horses of an advanced stage referred to the genus *Pliohippus*. The animals of these species were nearly as large as the smaller forms of the modern domestic horse. Their teeth were long-crowned and well adapted to grazing as in existing forms, but their feet still bore small side-toes somewhat as in *Merychippus* of the Barstow. The pattern of their teeth is quite unlike that of the *Hipparion* and considerable differences separate them in skeletal structure. They presumably occupied a different niche in the organization of the fauna, but what it was is not entirely clear.

In the Ricardo fauna, as at Barstow, we find a rare oreodon, the last representative of this important family known west of the Wasatch. The Ricardo type follows the rule in being more specialized than that in the Barstow Upper Miocene. Little deer-antelope much like those of Barstow are also known by the last representatives in the Great Basin. Rodents are rare. The mastodon group is still represented by animals with four tusks, a pair being present in the lower jaw as well as one in the upper jaw.

Of the camels there are several species known from Ricardo. They represent genera similar to those in the Barstow Miocene, but are generally of larger type, and are presumably in a large part specifically different. Carnivores are relatively abundant. Large heavy-headed ælurodons like those of Barstow are present, but possibly all belong to new species. With these are other forms of the same group, but larger and stronger. There is a marten of a new species. Of the cats, one is a saber-tooth of a rare type somewhat similar to a species known in India. One specimen, belonging to a gigantic animal of the *Felis* or true cat type, was at least as large as a male African lion of the present day. Another specimen is from a smaller cat possibly like a puma.

Large tortoises are known in the Ricardo, as at Barstow. At least one form seems to differ in its character from the Barstow species.

In the table on page 1285 a comparison of the Ricardo and Barstow faunas would show almost complete specific separation of the life stages. This difference extends in a considerable measure to groups of the rank of genera; as in the case of the horses, in which *Hipparion* replaces *Merychippus*. As has been noted above, in nearly all cases in which it has been possible to make a satisfactory comparison of animals in similar groups, the Ricardo types are seen

to be more specialized or more progressive.   In the Carnivora the common *Tephrocyon* of the Mohave seems to have disappeared. A single specimen shows some resemblance to that genus, but is not comparable to any Barstow species.   The heavy-jawed ælurodons, which are the characteristic canids of the Ricardo fauna, seem to be mainly, if not entirely, distinct, and are generally more specialized than those from the Barstow beds.

The fauna of the Ricardo beds is widely different from that of the Middle Miocene west of the Wasatch, and is distinctly more ad-vanced in the stage of progress or evolution.   It is quite different from the Lower Pliocene of Thousand Creek of Northern Nevada, and seems less advanced.   It differs so far as known from the Rattle-snake Lower Pliocene of Oregon, and is possibly somewhat older.

The beds in which the Ricardo fauna occurs were evidently de-posited on plains lying at the eastern base of a Pliocene Sierra range rising to a height of several thousand feet above the level of the Great Basin region.   The elevation of the Mohave area as a whole was probably not greater than at present, and may have been somewhat less.   The Ricardo deposits are probably in part land-laid and in part water-laid.   The volcanic material which they con-tain may at times have accumulated rapidly, but seems in general to have been deposited so slowly that the region was nearly con-tinuously habitable.

The Ricardo fauna consists largely of forms that would naturally prefer to inhabit plains areas, or might thrive in partly open, level regions at least as well as in other environment.   *Hipparion, Plio-hippus*, the camels, and *Merycodus* would find this a favorable habitat.   The carnivores associated with them would not neces-sarily find the surroundings unfavorable, provided sufficient cover were available.   The mastodons and oreodons might inhabit the plains or frequent the border of the mountain area to the west. There are no elements in the Ricardo fauna which are necessarily considered as representatives of a forest or mountain assemblage washed or carried out on the plains.

The Ricardo fauna suggests climatic conditions permitting the development of vegetation suitable for grazing animals.   This indicates a somewhat heavier growth of grass than is found in the Mohave at the present time.   There is nothing in the constitution of the fauna to suggest conditions radically different from those

obtaining in this region to-day, but the presumption is in favor of less extreme aridity than is now known on the western border of the desert. The conditions obtaining here in Ricardo time were probably more nearly like the present environment in the southern portion of the Great Valley of California.

The Latest Extinct Fauna of the Mohave, The Manix Pleistocene

The fragmentary remains obtained by Mr. Buwalda from the deposits of Manix Lake include only scattered bones and teeth with a few shells of snails and clams. The collection includes the bones of two horses of the genus *Equus*. One is a large species evidently closely related to the existing horses. The other is a much smaller form, but evidently of the same genus. There are two camels; one near the size of the dromedary, the other much smaller. The larger camel was probably near or incidental with the large *Camelops* known by splendid specimens from Rancho La Brea. The other species is unlike any Pleistocene camel described from the west. There are bones of a proboscidean, probably an elephant. A large antelope, probably like the pronghorn, is known by a single bone. Two birds like existing species are found in this fauna. The molluscs are fresh-water species closely related to living forms.

As fragmentary as is the material from the beds of Manix Lake, it represents the first assemblage of mammalian species of Pleistocene age from a definitely known horizon in the Mohave region. It is, in fact, the most important collection made at any single locality in the Pleistocene of the Great Basin. It gives for the first time a grouping of the most important mammalian forms living together in this region at any particular stage in the Pleistocene.

Taken alone these fragmentary specimens might never tell more than a very short story, but the wonderful Pleistocene collection obtained at Rancho La Brea just across the range to the west will ultimately furnish comparative material adequate to make possible a definite determination of the animal represented by every bone found in the Manix beds.

The Manix fauna is entirely distinct from that of the Ricardo. The horses are of the latest and most advanced genus, that is the modern *Equus*, which includes most of the living representatives of the horse group. The larger camels seem to represent the last

genus known in North America. The relationships of the smaller camel are as yet uncertain. If the antelope is near the pronghorn, as seems probable, it is also of the latest known type.

COMPARATIVE TABLE SHOWING KNOWN HISTORY OF THE MAMMALIAN FAUNAS IN THE MOHAVE AREA

Recent	Pleistocene	Pliocene	Miocene
DESERT FAUNA	MANIX	RICARDO	BARSTOW
Reptilia	*Reptilia*	*Reptilia*	*Reptilia*
Tortoise		Tortoise, large	Tortoise, large
Rattlesnake			
Carnivora	*Carnivora*	*Carnivora*	*Carnivora*
Desert coyote		Aelurodon, 3 species (Heavy-jawed dogs)	Aelurodon, 2 species (Heavy-jawed dogs)
Desert kit fox			Tephrocyon (Possible ancestor of modern wolves)
		Dog, small	Dog, very large
		Ischyrosmilus (Sabre-tooth cat)	Dog, small
Cougar		True cat, very large	Sabre-tooth cat, large
Desert wild cat		True cat, medium size	True cat, very large
California raccoon		Marten	
Spotted skunk			
Striped skunk			
Ungulata	*Ungulata*	*Ungulata*	*Ungulata*
	Equus, large (Horse)	Hipparion, 2 species (Advanced grazing-horse, 3-toed)	Hypohippus (Forest-horse, 3-toed)
	Equus, small (Horse)	Pliohippus, 2 or 3 species (Advanced grazing-horse, 3-toed)	Parahippus (Browsing-horse, 3-toed)
			Merychippus, 3 forms, abundant (Grazing-horse, 3-toed)
			Protohippus, rare (Advanced grazing-horse, 3-toed)
	Camelops? (Camel, large)	Procamelus?, (*a*) (Camel, small)	Procamelus (Camel, small)
	Camel, small	Procamelus?, (*b*) (Camel, small)	
		Alticamelus? (Tall camel)	Alticamelus?, (Tall camel)
		Pliauchenia? (Camel, very large)	Pliauchenia? (Camel, large)
		Merycochoerus?, (*b*) (Oreodon)	Merycochoerus (*a*) (Oreodon)

COMPARATIVE TABLE SHOWING KNOWN HISTORY OF THE MAMMALIAN FAUNAS IN THE
MOHAVE AREA—*Concluded*

Recent	Pleistocene	Pliocene	Miocene
DESERT FAUNA	MANIX	RICARDO	BARSTOW
Ungulata	*Ungulata*	*Ungulata*	*Ungulata*
Pronghorn antelope	Antelope, large (Pronghorn?)	Merycodus (Deer-antelope)	Merycodus (Deer-antelope)
			Merycodus? (Crowned deer-antelope)
			Dromomeryx (Antelope-deer)
Desert bighorn sheep			
	Proboscidea	*Proboscidea*	*Proboscidea*
	Elephant or Mastodon	Tetrabelodon? (Four-tusked mastodon)	Tetrabelodon? Four-tusked mastodon
Rodentia	*Rodentia*	*Rodentia*	*Rodentia*
Numerous genera and species	Fragments only	Fragments only	Fragments only

It is perhaps unnecessary to state that the Manix fauna differs from that of the present day in the inclusion of camels and a proboscidean. When it is better known, this fauna will probably be found to contain few if any modern species.

At the present time we are not in a position to state definitely the exact position or relationship of the Manix fauna with relation to other Pleistocene life in the west. The problem of the Pleistocene in this region is complicated and large, and the many elements still require much study before their interrelations can be determined. The Rancho La Brea fauna seems to contain elements similar to those of Manix, whether it is older or younger is not yet entirely clear.

The significance of the Manix fauna in relation to its environment is unfortunately not large. The presence of camels, horses, and antelopes indicates a climate somewhat more humid than that in this region at the present time, and such was the suggestion furnished by Mr. Buwalda's work on the physical history of the Manix Lake basin.

### SIGNIFICANCE OF THE FAUNAL SUCCESSION IN THE MOHAVE

The physical history of the Mohave area, in the time that has passed since the accumulation of the oldest formation containing a mammalian fauna in this basin, is only a small part of the long and

complicated geologic story of the region; but the changes that have occurred since the earliest of these records of life were completed take on stupendous proportions when measured against human standards of stability.   Since the deposition of the oldest beds of the Barstow section, not less than 8,000 ft. of known sediments have been laid down in this region, and there are evidences of long periods from which the only record that we have is of erosion instead of deposition.   The strata of both the Barstow and Ricardo sections have been subjected to extreme movements of the earth's crust in folding and faulting or breaking.   They have also been extensively eroded or worn down, and the strata now exposed can be considered only as remnants of the original mass.   In terms of accumulation and erosion of deposits, judged by the best estimates that we can make, the lapse of time since burial of the oldest mammal remains in this region must be very long.

Physical changes of great significance in the history of this region, and of the life in it, are also noted in variations in the nature of the bordering mountain ranges.   At present the Mohave owes its distinctive characters in large measure to separation from the Pacific coast by high ridges to the west.   Throughout a large part of the known life history of this region, a barrier seems to have existed between the Mohave area and the Pacific Coast province.   The height of the separating wall has presumably varied much, being relatively small in Miocene time, and probably reaching its maximum since the Ricardo Pliocene.   Variation in height of the barrier depended on the balance between erosion constantly wearing it down, and on the magnitude of crustal movements concerned in the making of the mountain chains.   To some extent variation in physical conditions in the Mohave has therefore been related to stages in the life of our great ranges.   The latest period in the history of the mountains is the stage in which the peaks and valleys were modeled to their present form through gradual wearing down by ice, water and chemical decay.   The clearly visible evidences of this last epoch mark for us a period longer than the full span of human history.   In the story of the mountains, the earlier stages standing in relation to the history of life on the Mohave are observed only through study of a complicated geologic problem, but the measure of these early stages in time is far longer than that of the latest epoch.

The Barstow, Ricardo and Manix faunas present three stages in the life history of the Mohave area within the extent of a long period marked by many great physical changes. The records of these faunas are incomplete, and should be considered only as imperfect pages from a volume that has passed through fire, flood, earthquake and decay incident to the passage of almost limitless time. As fragmentary and unsatisfactory as the story is, it opens to us a wide vision of previously unknown life history in this region; it offers significant evidence regarding the origin, evolution and migration of important mammal groups; it furnishes information concerning the climatic history of the Mohave; and it contributes largely to our knowledge of the chronology of great crustal movements in western North America. If this were the only record known in the world, from it alone we could gather evidence that the life of the earth is very old, that this life has completely changed from time to time, and that in each successive fauna there was a nearer approach to the life types now in existence. We might not be able from the Mohave story to demonstrate the fact of evolution, as the fragments are small, and represent periods so widely separated that the suggestion of continuity is indistinct. Taken in connection with the great volume of records now available from other regions of the world, the Mohave story serves in a modest way to fill gaps in the previously known history; and in its close relationship to faunas remotely separated from it geographically, it illustrates the faunal unity of the world as a whole when the broader outlines of evolution are followed through long periods.

The story of the Mohave read alone cannot do less than impress one with the magnitude of faunal changes and with their apparent definite trend toward the life of to-day. Related to other records, it becomes a part of the great world-scheme of life growth or evolution leading up through the ages to the present living world of which we are a part.
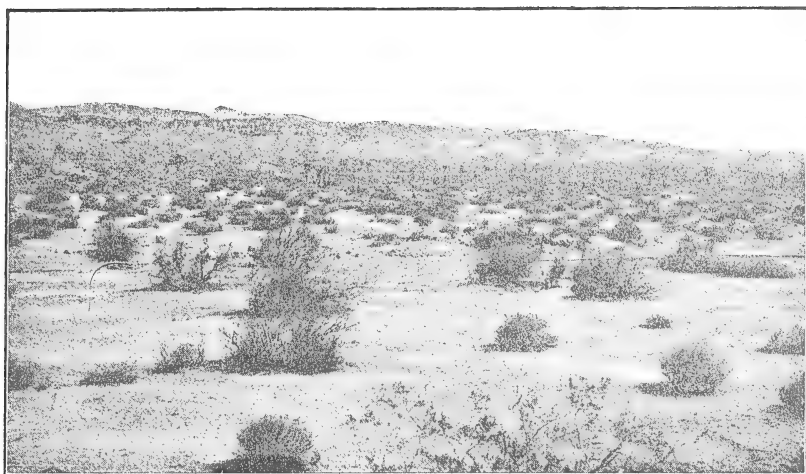
Characteristic view of the Mohave Desert in the vicinity of the fossil beds.
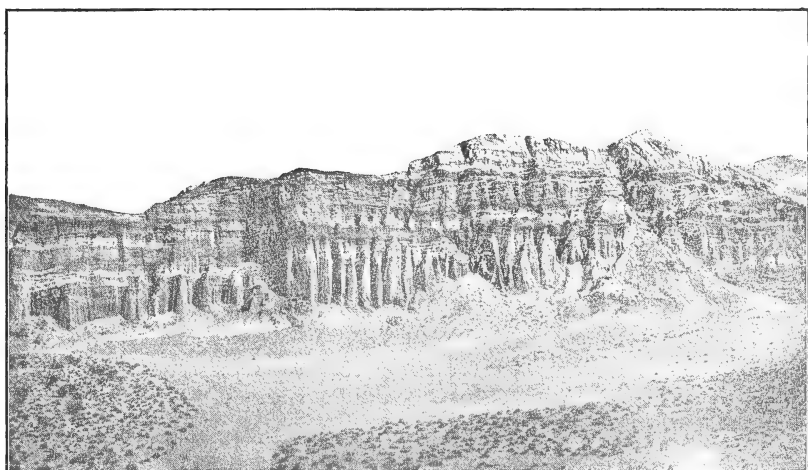(Photograph by C. L. Baker)
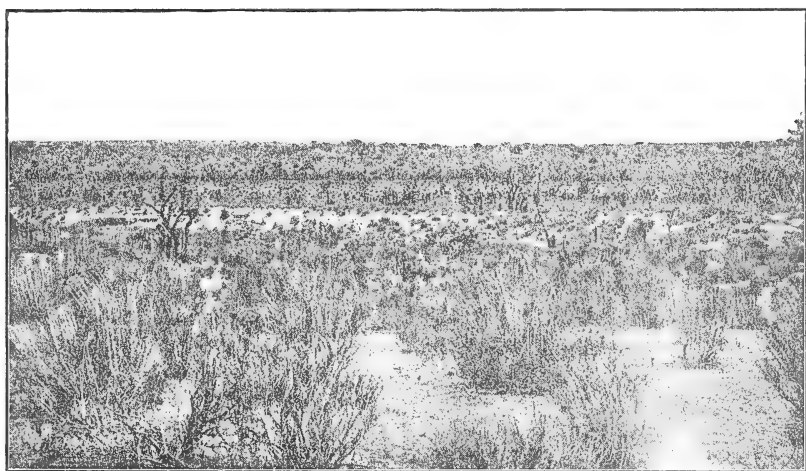
Characteristic view of the Mohave Desert; showing at this locality an unusual
abundance of vegetation, consisting of creosote bushes and Joshua trees.
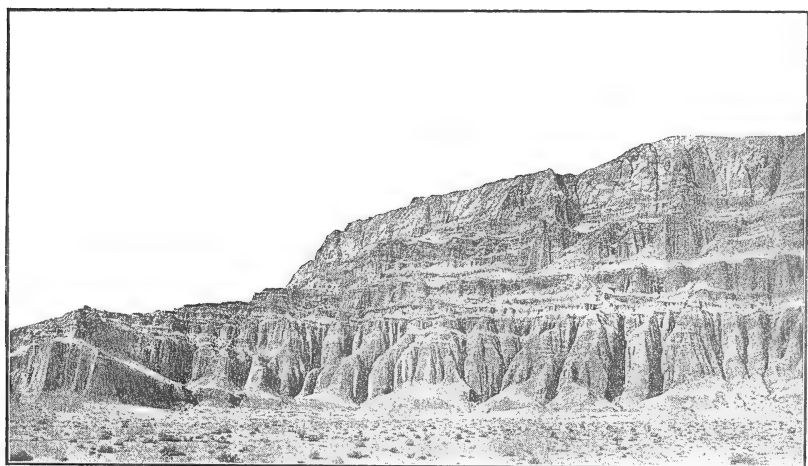(Photograph by C. L. Baker)
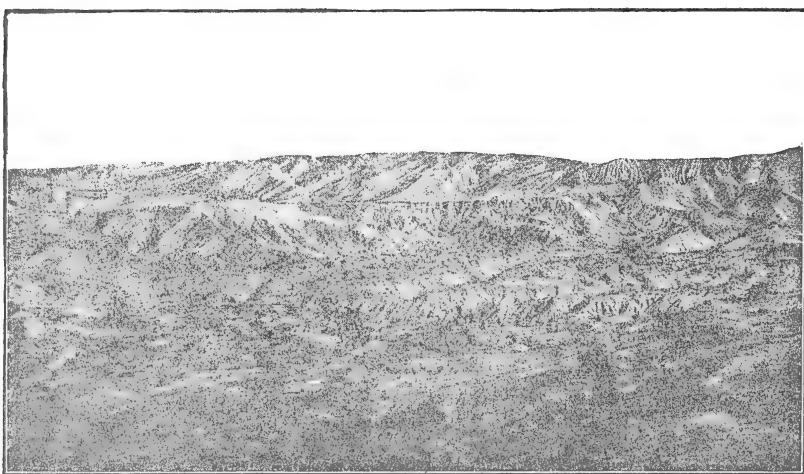
Typical exposure of the fossil-bearing Barstow Miocene formation north of Barstow. (Photograph by C. L. Baker)
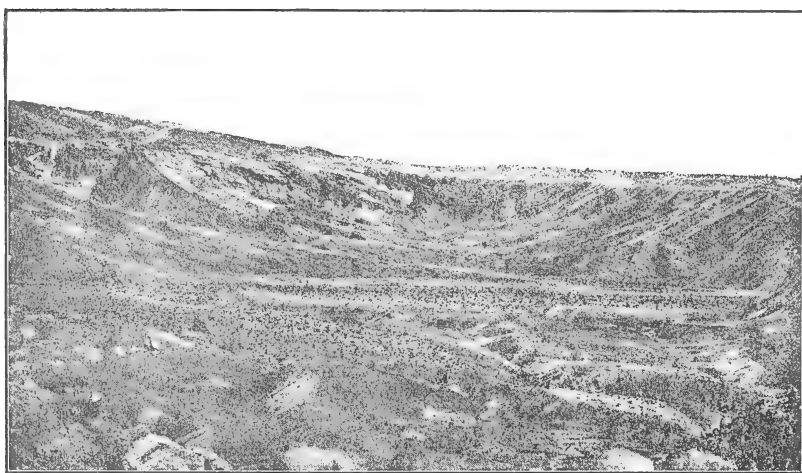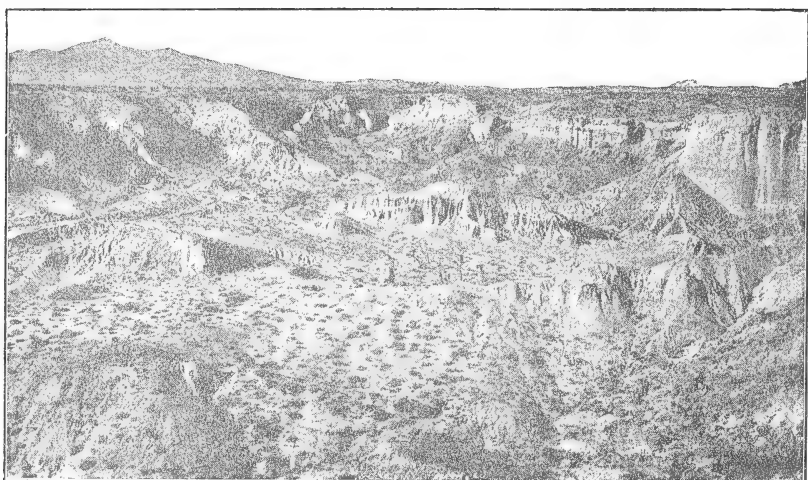

Folded and faulted strata representing a portion of the section containing fossil remains north of Barstow. (Photograph by C. L. Baker)

Typical exposure of the Ricardo Pliocene near Ricardo. (Photograph by C. L. Baker)
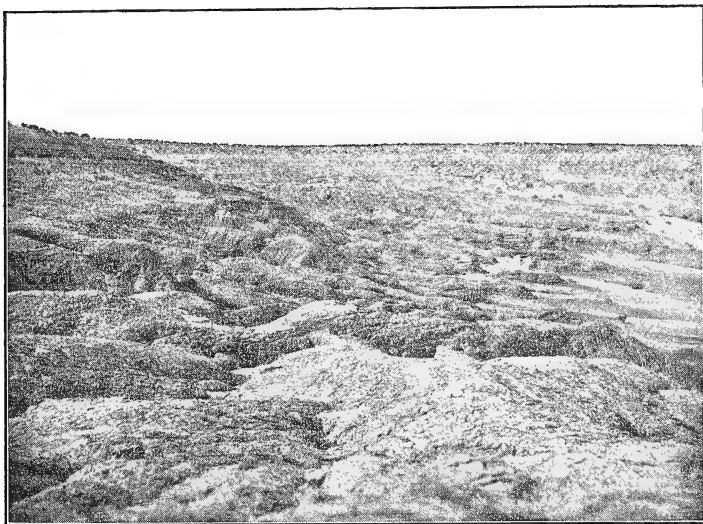

Exposures of Ricardo Pliocene, showing characteristic bad-land structure in outcrops near Ricardo. (Photograph by C. L. Baker)
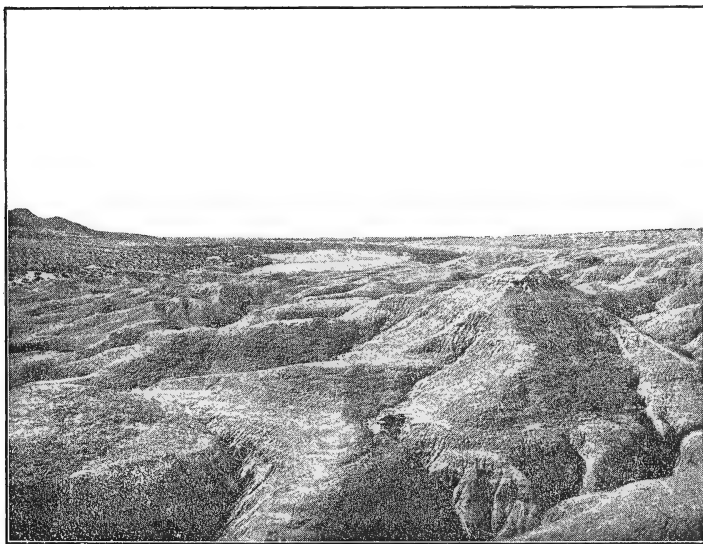
A basin in the Ricardo Pliocene near Ricardo. (Photograph by C. L. Baker)
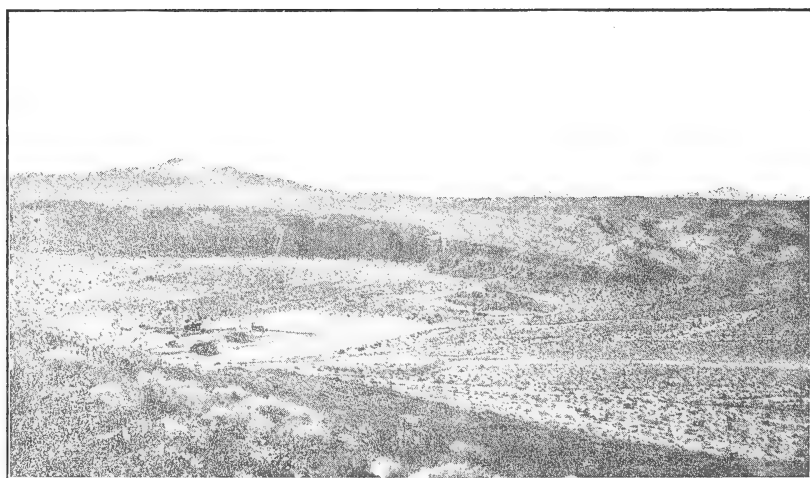
Ricardo Pliocene at Ricardo. This is one of the most important fossil localities in the Ricardo formation. (Photograph by C. L. Baker)
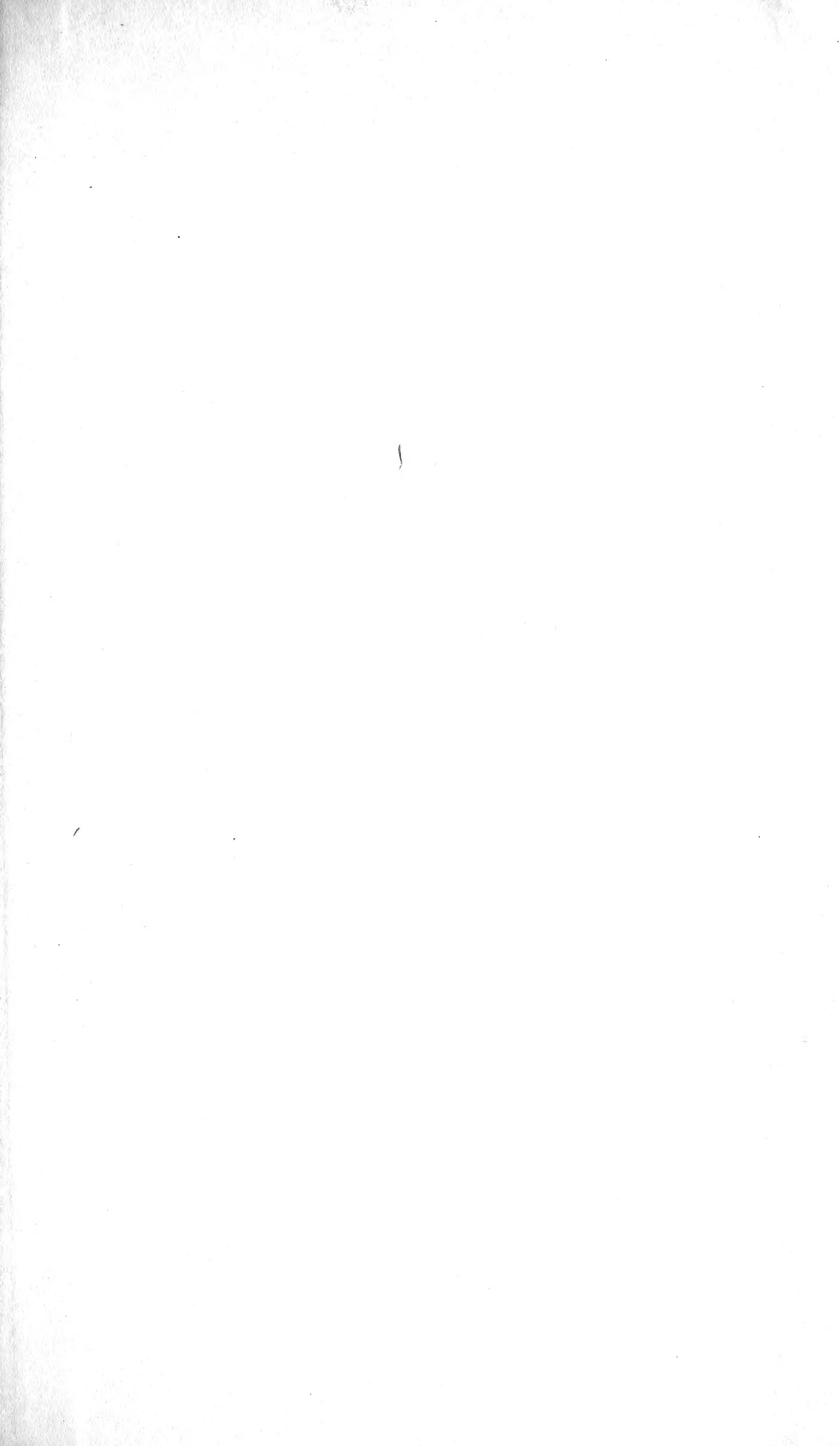
Characteristic exposure of the Manix Pleistocene lake-beds on the north
bank of the Mohave River near field station in the Manix Basin.
(Photograph by J. P. Buwalda)

Bad-land structure in the Manix Basin.   (Photograph by J. P. Buwalda)